SECTION 441130

WET FLUE GAS DESULFURIZATION SYSTEMS

PART 1 – GENERAL

101. GENERAL TECHNICAL REQUIREMENTS

101.1. General

a. This Section defines the design basis, performance requirements, flow modeling requirements and major component requirements for the two (2) wet flue gas desulfurization (WFGD) systems. The CONTRACTOR shall conform to the requirements of this Section as required for the Work and to the requirements indicated on the reference drawings.

As stated in Section 011100, the scope of work includes two WFGD systems (one each for GGS Units 1 & 2), a common reagent processing system, a common dewatering system, and associated facilities. Two new wet chimneys and four new booster fans will be supplied by Others.

b. The CONTRACTOR's design and supply shall be such that components, parts, and modules shipped to the site and / or field are fabricated to the largest and most complete extent possible in the shop, consistent with good engineering practices and to the maximum dimensions allowed by shipping limitations. The amount of site and / or field work and welding shall be minimized.

c. For systems and facilities included in the scope of work contained herein, the design, configuration and layout including platforms, stairs, equipment and component removal pathways and hatches shall facilitate safe and efficient operations and maintenance. The CONTRACTOR shall provide all platforms and stairs for appropriate access to and egress from all areas, both indoors and outdoors, requiring access for operation and maintenance. These areas include, as a minimum, access to man-doors, valves, operators, drives, expansion joints, test ports, instrument connections and observation areas. The CONTRACTOR shall provide jib cranes, monorails, and hoists that are required to service equipment and remove any tank access doors and man-hole covers. Lifting equipment and platforms for agitators shall be by the CONTRACTOR. Access shall be provided for internal inspection of the flue gas path including ducts, expansion joints and all absorber internals.

d. CONTRACTOR shall lay out, arrange, and size all trenches and sumps required to collect operating and maintenance drains, flush water, and washdown water from all CONTRACTOR equipment, piping, valves, and process areas. CONTRACTOR and DISTRICT's Project Engineer shall mutually agree on the arrangement and sizes of trenches and sumps.

e. CONTRACTOR shall supply automatic and manually initiated flush and drain connections for all limestone slurry, recycle, bleed, and underflow piping systems. Drain and flush valves by the CONTRACTOR shall be equipped with air operators equipped with air regulators to adjust the speed of operation of the valve. The drains shall be adequately sized and be routed to WFGD tanks, sumps and drain trench system. Drains shall be provided at all low points. Piping between the CONTRACTOR'S reclaim water system and the flush connections and between the drain connections and the discharge terminal locations shall be by CONTRACTOR.

f. As detailed herein, the WFGD systems shall contain features that will allow integration with possible future CO_2 capture systems.

g. For systems and facilities included in the scope of work contained herein, the equipment and components shall be properly protected from the environment and ambient temperature conditions as specified herein.

h. Each new chimney will be operated in a wet condition and the WFGD systems shall be designed to treat 100% of the specified flue gas volume without flue gas reheat or flue gas bypass.

i. CONTRACTOR shall reuse reclaimed water to the largest extent possible. Makeup water will be made available by the DISTRICT.

j. CONTRACTOR'S design of absorber building structures, piping, and pipe supports shall consider the differential movement between the absorber and the building steel due to wind, seismic, and thermal forces.

101.2. General Arrangements and Process Flow Diagrams

a. CONTRACTOR's equipment shall be located in general accordance with the available area shown on the drawings as specified herein. Each WFGD system shall be located downstream of the new induced draft booster fans and upstream of a new chimney. The locations of the chimneys, reagent unloading facility, pipe racks, roads and major WFGD structures have been established by the DISTRICT in consideration of construction requirements, plant access considerations, and possible future CO_2 capture equipment. The CONTRACTOR is encouraged to optimize equipment arrangements within the areas indicated on the site general arrangement drawing.

b. Reference general arrangement drawings showing underground interferences, available pipe route corridors and necessary access are provided in Section I - Contract Drawing and Data Requirements.

c. As the general arrangements for systems and facilities included in the scope of work contained herein, are developed, variations and modifications to CONTRACTOR's arrangement may be necessary. Such modifications shall be effected at no additional cost to the DISTRICT as long as no material increase is necessary.

102. WFGD SYSTEMS DESIGN

102.1. Design and Operating Data

a. For systems and facilities included in the scope of work contained herein, systems shall be designed for the operating conditions specified including the Design Fuel Analyses, the Limestone Analysis, Make-Up Water Analysis, and WFGD Inlet Gas Analysis as specified herein. The WFGD systems, reagent preparation system, and dewatering system shall be designed and constructed such that all performance guarantees specified shall be met for operation with the full range of fuels and limestone quality specified herein.

b. For systems and facilities included in the scope of work contained herein,, the systems shall be designed to treat flue gas created from firing the following fuel being burned in the units.

Design Fuel Analysis

	Design Fuel
Carbon	**51.46**
Hydrogen	**3.67**
Nitrogen	**0.73**
Sulfur	**0.75**

Oxygen	**10.47**
Chlorine	**0.01**
Fluorine	**0.01**
Moisture	**27.10**
Ash	**5.80**
HHV (Btu/lb)	**8,979**

c. Mine data for fuel and ash for individual fuels which are candidates to be blended or fired independently in Units 1 and 2 are contained in this Section, Attachment 2. The range of SO_2 in the coal will be between 0.7 lb SO_2/mmBtu and 2.26 lbs SO_2/mmBtu. The GGS units will operate firing any of these fuels.

c1. The design fuel analysis has a sulfur content representative of the expected sulfur for the coal to be burned at GGS. This coal shall be used to determine typical operating conditions at GGS and to estimate expected performance.

d. Operating Scenarios:

d1. Currently, the Units operate at base load with less than 20 hot starts (off-line for less than 48 hours) and cold starts per year per unit.

e. Load:

e1. Unit Rating of Generating Equipment (URGE load) is the operation with valves wide open, with a string of high pressure heaters out of service for Unit 1 (one HP heater for Unit 2), and with turbine throttle pressure controlled as required between 2,400 to 2,520 psig.

e2. URGE load shall be the maximum load that the Units currently operate at.

e3. Intermediate load shall be selected to be between minimum load and URGE load.

e4. Minimum load is 35% of URGE load.

f. Equipment sizing shall be based on parameters included in the table below.

Flue Gas Conditions		
	Design Fuel and URGE Load	
	GGS Unit 1	GGS Unit 2
URGE Load, MW	705	745
Heat Input to Boiler (mmBtu/hr)	6,988	7,322
Design SO_2 Inlet Loading (lb/mmBtu)	1.669	1.669
Economizer Outlet O_2 (% O_2 on a wet basis)	3.42	2.84
Total Leakage Upstream of WFGD (%)	16.0	23.4
Temperature @ WFGD Inlet (°F)	355	336
Pressure @ WFGD Inlet (in.	+9	+9

w.g.)		
Calculated Gas Flow @ WFGD Inlet (acfm)	3,167,636	3,338,305
Calculated Gas Flow @ WFGD Inlet (lb/hr)	8,434,725	9,097,772
Calculated Flue Gas Composition @ WFGD Inlet		
N_2, %	71.83	72.00
O_2, %	5.80	6.22
CO_2, %	11.48	11.15
H_2O, %	10.83	10.57
SO_2, ppmv, wet	625	607
SO_3, ppmv, dry (@3%O_2) (without SCR)	2.0	2.0
SO_3, ppmv, dry (@3%O_2) (with SCR)	10.0	10.0
NH_3, ppmv, dry (@3%O_2) (without SCR)	0	0
NH_3, ppmv, dry (@3%O_2) (with SCR)	2.0	2.0
Particulate emission, lb/mmBtu	0.015	0.015
Particulate emission, lb/hr	108	114

Note: The data in the table above is based on +1" w.g. at the chimney breech. This can vary between +1" w.g. and -2.0" w.g.

g. Filterable particulate matter in the flue gas leaving the boiler will be removed by the DISTRICT's reverse air baghouse prior to entering the WFGD system. CONTRACTOR's equipment shall be designed to operate in a continuous manner with no loss of SO_2 removal performance for an expected particulate loading defined above, as well as during occasional upsets in operation of the particulate collector when the efficiency will drop below the expected value.

h. As previously noted, CONTRACTOR's equipment shall be designed to accommodate the installation of a hot-side, high-dust SCR system on each GGS unit.

i. The systems shall be designed for normal load changes of 10 MW per minute. In an emergency, such as an FD or ID fan trip, the systems shall be capable of responding to a 100 MW per minute runback without causing the generator unit to trip.

j. Flue Gas Path Design Parameters:

j1. Continuous operating design parameters for the flue gas path are as follows:

Location	**Absorber Inlet and Upstream Ductwork**	**CONTRACTOR-Supplied Absorber**	**CONTRACTOR-Supplied Absorber Outlet Ductwork and Downstream Ductwork**

Continuous condition	40°F to 400°F -15 in. w.c./+25 in. w.c.	40°F to 180°F with recycle spray or emergency quench system in operation -15 in. w.c./+25 in. w.c.	40°F to 180°F with recycle spray or emergency quench system in operation -6 in. w.c./+5 in. w.c.

j2. Short term upset pressure design parameters for the flue gas path are as follows:

Location	**Absorber Inlet and Upstream Ductwork**	**CONTRACTOR-Supplied Absorber**	**CONTRACTOR-Supplied Absorber Outlet Ductwork and Downstream Ductwork**
Excursion condition due to draft system upset for 30 minutes	40°F to 400°F -15 in. w.c./+35 in. w.c.	40°F to 180°F with recycle spray or emergency quench system in operation -25 in. w.c./+35 in. w.c.	40°F to 180°F with recycle spray or emergency quench system in operation -6 in. w.c./+5 in. w.c.

j3. Short term upset temperature design parameters for the flue gas path are as follows:

Location	**Absorber Inlet and Upstream Ductwork**	**CONTRACTOR-Supplied Absorber**	**CONTRACTOR-Supplied Absorber Outlet Ductwork and Downstream Ductwork**
Excursion condition due to loss of air heater for 30 minutes	750°F -15 in. w.c./+25 in. w.c.	180°F with recycle spray or emergency quench system in operation -15 in. w.c./+25 in. w.c.	180°F with recycle spray or emergency quench system in operation -6 in. w.c./+5 in. w.c.

Assume baghouse in bypass. Full ash load through system.

j4. Short term upset temperature design parameters for the flue gas path are as follows:

Location	**Absorber Inlet and Upstream Ductwork**	**CONTRACTOR-Supplied Absorber**	**CONTRACTOR-Supplied Absorber Outlet Ductwork and Downstream Ductwork**
Excursion condition due to station blackout and loss of station power except for battery backup	For 0 to 30 minutes 750°F and -15 in. w.c./+15 in. w.c. For the next 30 minutes 650°F and -15 in. w.c./+5 in. w.c.	For 0 to 30 minutes 180°F with emergency quench system in operation and -15 in. w.c./+25 in. w.c. For each subsequent	For 0 to 30 minutes 180°F with emergency quench system in operation and ± 10 in. w.c. For each subsequent

	For each subsequent 30 minute period the temperature will be 50°F lower than the previous and -15 in. w.c./+5 in. w.c.	30 minute period the temperature will be 180°F and -15 in. w.c./+5 in. w.c.	30 minute period the temperature will be 180°F and ± 5 in. w.c.

Assume baghouse in bypass. Full ash load through system.

j5. The 180°F temperature listed above is the design temperature for the flue gas with the emergency quench system in operation.

j6. The above continuous and excursion design parameters are based on the DISTRICT providing NFPA furnace implosion protection for the Units.

j7. The flue gas path beginning at the CONTRACTOR's ductwork terminal location shall be designed to comply with NFPA 85 requirements for both normal operating and excursion pressure and temperatures.

102.2. Systems Operation

a. The systems and facilities included in the scope of work contained herein shall be designed and constructed to operate at URGE load or any specified partial load over a design life of 30 years with normal maintenance required and maximum availability.

b. The systems and facilities included in the scope of work contained herein shall be designed to achieve a high availability and low forced outage rate as defined herein.

c. The units are currently operating two years between major outages, each of which is normally scheduled for 6 weeks duration. The systems included in the scope of work contained herein shall be designed for installation such that the DISTRICT does not have to take any additional outages or increase the normally scheduled outage durations. CONTRACTOR shall note that this item is included in the Evaluation Factors.

d. The systems and facilities included in the scope of work contained herein shall be designed for continuous operation over the range of conditions specified herein and any operation during startup and transient conditions. CONTRACTOR shall note that gas temperature, pressure, flow, and constituents will change considerably during load changes for each of the units.

e. The systems and facilities included in the scope of work contained herein shall produce wall-board grade gypsum for individual and dual unit operation with a target solids content of 90%.

f. The DISTRICT will provide make-up water at CONTRACTOR's terminal location for use in the absorber, the emergency quench system, and mist eliminator wash. The water analysis is specified in Attachment 4 herein. The CONTRACTOR shall provide the piping systems necessary to supply the required water to the required equipment.

g. Reclaim water from the dewatering system shall be returned to each absorber or reagent preparation area. The reclaim water shall be returned on a 24-hour basis, regulated by the demand of each WFGD system. Reclaim (surge) capacity shall be provided by CONTRACTOR.

103. EQUIPMENT REDUNDANCY

103.1. The systems and facilities included in the scope of work contained herein shall be designed so that the failure of a component shall not cause a system to be taken off-line for service. For some tanks or components, an installed spare will not be required.

103.2. Below is a table detailing the equipment redundancy requirements that must be met by the CONTRACTOR.

ABSORBER AREA	
Absorber Module	1 x 100% per Unit
Absorber Spray Levels	N operating plus 1 Spare level per Absorber
Absorber Recycle Pumps	One per spray level
Absorber Recycle Tank Agitators	Design mixing and suspension must be achieved with any one agitator out of service
Oxidation Air Compressors	2 x 100% per Absorber
Emergency Quench Pump (Diesel driven)	2 x 100% per Absorber
Absorber Bleed Pumps	2 x 100% per Absorber
ME Wash Water Tank	1 x 100% per Absorber
ME Wash Water Pumps	2 x 100% per Absorber
Hydroclone Cluster	1 x 125% per Absorber
Hydroclone Underflow Tank	1 x 100% per Hydroclone Cluster
Hydroclone Underflow Agitator	1 x 100% per Hydroclone Underflow Tank
Hydroclone Underflow Pumps	2 x 100% per Hydroclone Underflow Tank
REAGENT PREPARATION AREA	
Wet Ball Mills	2 x 100% per Station
Limestone Silo	1 x 100% per Wet Ball Mill
Limestone Weigh Feeder	1 x 100% per Wet Ball Mill
Mill Product Tank	1 x 100% per Wet Ball Mill
Mill Product Tank Agitator	1 x 100% per Mill Product Tank
Mill Product Pumps	2 x 100% per Mill Product Tank
Wet Ball Mill Classifier	1 x 125% per Wet Ball Mill
Limestone Slurry Tanks	2 x 100% per Station
Limestone Slurry Tank Agitator	1 x 100% per Limestone Slurry Tank
Limestone Slurry Feed Pumps	2 x 100% per Limestone Slurry Tank
Limestone Slurry Feed Loops	2 x 100% per Unit
Maintenance Slurry Storage Tank	1 x 100% Station Capacity
Maintenance Slurry Storage Agitator	1 set constituting 100%
Maintenance Slurry Storage Pumps	2 x 100% per Maintenance Slurry Tank

ABSORBER AREA	
GYPSUM DEWATERING AREA	
Flush Water Pumps	2 x 100%
Reclaim Water Tanks	2 x 50% per Station
Reclaim Water Pumps	2 x 100% per Reclaim Water Tank
Filter Feed Tank	2 x 50% 24 hour Station Capacity
Filter Feed Tank Agitator	1 x 100% per Filter Feed Tank
Filter Feed Pumps	2 x 100% per Filter Feed Tank
Belt Filter Trains	2 x 100% per Station
Filtrate Feed Pump	1 x 100% per Belt Filter Train
Filter Vacuum Pump	1 x 100% per Belt Filter Train
Filter Filtrate Receiver	1 x 100% per Belt Filter Train
SUMPS AND DRAINS	
Sump Pits and Trenches (Design Only)	As required
Sump Pump	2 x 100% per Sump Pit
Sump Agitator	1 x 100% per Sump Pit
MISCELLANEOUS	
Instrument/Service Air Compressors, Receivers, and Dryers	2 x 100% Unit Capacity 1 Instrument Air Receiver, 1 Service Air Receiver

104. GUARANTEES AND PERFORMANCE TESTS

104.1. The performance guarantees listed below shall be met by each unit based on the total range of design conditions herein specified. See Section 104.18 for an explanation of Test A and Test B.

a. The following performance guarantees are designated 'Make Right' or Unlimited Liability. Refer to Section C – Proposal.

'Make Right' or Unlimited Liability Performance Guarantees for Each Unit

Guarantee Required	Guarantee Value	Test
SO_2 Outlet Concentration	3-Hour Average: 0.045 lb/mmBtu @ FGD Outlet, and 30-Day Weighted Rolling Average: 0.08 lb/mmBtu @ CEMS	A & B
Filterable Particulate Emission Rate	No Net Particulate Addition	A & B
Condensable Particulate Emission Rate	Guarantee emission rate value is by CONTRACTOR	A & B
Entrained Moisture Carryover at Outlet of Mist Eliminator	Maximum of 0.070 grains/scf	Scale Model Lab Test

'Make Right' or Unlimited Liability Performance Guarantees for Each Unit

Guarantee Required	Guarantee Value	Test
Velocity Distribution at Mist Eliminator Outlet	Maximum RMS of ± 15.0%	Test A
Oxidized Hg Removal Efficiency	90 % Removal	A & B
SO_3 Removal Efficiency	Guarantee % Removal value is by CONTRACTOR	A & B
HCl Removal Efficiency	Guarantee % Removal value is by CONTRACTOR	A & B
Total Non-Mercury Metals Concentration	Maximum of 40 lb/TBtu	A & B
Gypsum Oxidation Level	99+%	A & B
Ball Mill Capacity and Grinding Fineness	95% through 325 mesh at throughput of 40 tons/hr	A & B
Noise	≤ 85 dBA @ 1 meter	Test A

b. The following performance guarantees are associated with specific Remedies and/or Liquidated Damages as detailed in the Commercial Terms and Conditions.

Performance Guarantees for Each Unit. Refer to Commercial Terms and Conditions for Remedies for Failure to Comply

Guarantee Required	Guarantee Value	Test
Flue Gas Total Pressure Drop (IWC) from CONTRACTOR's Inlet Ductwork Flange through CONTRACTOR's connection to Chimney Breeching	Guarantee Value is by CONTRACTOR	A
FGD Power Consumption (kW) Reagent Preparation/Dewatering Power Consumption (kW)	Guarantee Values are by CONTRACTOR	A
Maximum Limestone Consumption & Limestone Stoichiometric Ratio	Guarantee Value is by CONTRACTOR (lb/hr). Guarantee Value verified by using Limestone Stoichiometric Ratio	A & B
Wall-Board Grade Gypsum Minimum Solids Content Minimum Sulfate Content Maximum Sulfite Content Maximum $CaCO_3$ Content Maximum SiO_2 Content Total Water Soluble Salts (2) Mass Mean Particle Size	 90% 95% 0.5% 1.5% 1.5% 100 ppm 20 – 75 microns	A & B
Equivalent Availability Guarantee (12	Equivalent Forced Outage	Between

Performance Guarantees for Each Unit. Refer to Commercial Terms and Conditions for Remedies for Failure to Comply

Guarantee Required	Guarantee Value	Test
months after successful completion of Test A for each Unit)	Rate < 1.0%	Successful Completion of Tests A & B for each Unit

104.2. SO_2 Outlet Concentration: The maximum SO_2 outlet concentration of the absorber shall be guaranteed as specified herein for each unit with the flue gas conditions as specified herein without the use of performance enhancing additives such as organic acids. This outlet concentration shall be met at all operating loads while firing the full range of fuels, as specified herein.

104.3. Filterable Particulate Removal: For each unit, the filterable particulate emission level in the chimney shall not exceed the level at the absorber inlet. This emission level shall include fly ash, calcium salts, ammonia and other inerts or materials, except water in uncombined form, that are or have been airborne, and exist as liquid or solid at standard conditions. The emission level shall be met at all operating points and be based on the heat input to the boiler at that operating load.

104.4. Condensable Particulate Removal: For each unit, the condensable particulate emission level in the chimney shall not exceed the level guaranteed by the CONTRACTOR . The emission level shall be met at all operating points and be based on the heat input to the boiler at that operating load.

104.5. Pressure Drop: The CONTRACTOR shall guarantee a total pressure drop through the WFGD system in inches of water column (IWC) for the URGE load flue gas flow, while operating at the maximum allowable mist eliminator pressure difference. This value shall be calculated from the DISTRICT/CONTRACTOR interface of the WFGD absorber inlet battery limit to the absorber module outlet duct interface at the chimney breeching. The mist eliminator and all ducts shall be in a normal operating condition based on CONTRACTOR's recommended mist eliminator cleaning cycle. CONTRACTOR shall provide pressure taps, as needed, for the guarantee test and show the location of the taps on their drawings.

104.6. Mist Eliminator Performance: For each absorber, the Maximum Entrained Moisture Carryover as measured in a demonstration model test shall be per the table in Article 104.1.a based on the absorber cross section at the mist eliminator level and the design flue gas velocity. The flow model shall include the exact type and configuration of mist eliminators being proposed and shall be tested with and without the mist eliminator sprays in service.

For each absorber, the velocity distribution at the downstream side of the mist eliminator as measured in a field test shall be an average of no more than 15.0% RMS based on the absorber cross section at the mist eliminator level and the design flue gas velocity. CONTRACTOR shall provide 8 evenly spaced test ports at the test location for the use during the velocity distribution test, and guide rods to be used to support the velocity probe within the absorber vessel. A minimum of 48 sample points shall be used to measure the velocity distribution.

104.7. SO_3 Removal: For each unit, a maximum SO_3 emission rate shall be guaranteed at all operating loads when firing the design fuel within the range of constituents, and at a maximum WFGD inlet value of 10 ppm, while using the forced oxidation limestone operating mode and without the use of performance enhancing additives.

104.8. HCl Removal: For each unit, a minimum HCl removal efficiency shall be guaranteed at all operating loads when firing the design fuel within the range of constituents, while using the forced oxidation limestone operating mode and without the use of performance enhancing additives.

104.9. Oxidized Mercury Removal: For each unit, a minimum removal efficiency of WFGD inlet oxidized mercury shall be guaranteed at all operating loads when firing the design fuel within the range of constituents, while using the forced oxidation limestone operating mode. Mercury re-emitted from the absorber in any form shall be deducted from the mercury captured.

104.10. Total Non-Mercury Metals Concentration: The maximum non-mercury metals outlet concentration of the absorber shall be guaranteed as specified herein for each unit with the flue gas conditions as specified herein. This outlet concentration shall be met at all operating loads while firing the full range of fuels, as specified herein.

104.11. Auxiliary Power Consumption Guarantee:

a. The continuous Power Consumption required while meeting other performance guarantees. CONTRACTOR shall provide separate Power Consumption Guarantee values for each WFGD system, (which includes all Recycle Pumps, Oxidation Air Compressors, and other appurtenant equipment required to meet the other performance guarantees), and Reagent Preparation/Dewatering Equipment(which includes Ball Mills, Vacuum Filters, and other appurtenant equipment required for reagent preparation and dewatering processes). The auxiliary power consumption will be measured at the switchgear and/or motor leads and averaged over a 24-hour operating period, or a mutually agreeable duration during which all equipment within the system is operating. The Power Consumption will be measured at the URGE load for the design fuel and shall not exceed the CONTRACTOR's guaranteed values.

b. The 7.2 kV medium voltage switchgear supplier shall supply protection CT's on all three phases (0.3% accuracy or better). For power consumption testing, these CT's will be used. The motor management relays must be capable of motor power measurement and indication.

104.12. Limestone Consumption and Stoichiometry: For each absorber, the Limestone Consumption in lb/hr for the URGE load while firing the design fuel shall be guaranteed for each WFGD system. The limestone stoichiometric ratio shall not exceed CONTRACTOR's guaranteed value for each unit when operating at the flue gas conditions specified herein, and is defined as the molar ratio of available calcium carbonate ($CaCO_3$) divided by the SO_2 removed.

a. Adjustments shall be made to the guaranteed limestone consumption in the event of deviations in the content (or reactivity) of $CaCO_3$. Moreover, an adjustment in limestone consumption shall be made in the event sulfur levels differ from those present in the design fuels.

104.13. Gypsum Oxidation: For each absorber, the Oxidation Level of the Gypsum Product shall be per the table in Article 104.1.a at URGE- load and design SO_2 operation. Oxidation Level shall be calculated by dividing the total moles of Calcium Sulfate ($CaSO_4 \cdot 2\ H_2O$) by the sum of the total moles of Calcium Sulfite ($CaSO_3 \cdot \frac{1}{2}\ H_2O$) and Calcium Sulfate in the gypsum product from the absorbers, expressed as a percentage.

104.14. Wall-Board Grade Gypsum: For each absorber, the minimum solids content shall be per the table in Article 104.1.b at URGE load and SO_2 operation. The gypsum quality shall be tested as specified below.

Gypsum Quality Test Methods

Guarantee Required	Test Method
Minimum Solids Content	ASTM C471
Minimum Sulfate Content	ASTM C471 or EPRI L4
Maximum Sulfite Content	EPRI M3
Maximum $CaCO_3$ Content	Combined ASTM C25/TAPPI T624 or EPRI N3
Maximum SiO_2 Content	ASTM C471
Total Water Soluble Salts (2)	Mutually agreed upon method
Mass Mean Particle Size	Laser Diffraction, e.g. MICROTRAC or MALVERN

104.15. Ball Mill Fineness: Ball mill capacity and fineness – CONTRACTOR shall guarantee a ball mill capacity of 40 tons per hour while producing a product particle fineness of 95% through 325 mesh.

104.16. Equivalent Availability Guarantee

a. CONTRACTOR shall guarantee the Equivalent Availability of two sets of equipment, the first set of equipment being the WFGD system brought on-line first and the reagent preparation/dewatering equipment, the second set being the WFGD system that is brought on-line second. The EAF shall be calculated and compared to the guarantee value for these two sets of equipment independently. Equivalent availability terms: equivalent availability is defined as follows:

a1. "Equivalent Availability Factor," EAF = (PH-POH-FOH)/ (PH- POH).

a2. "Planned Outage Hours," POH = the time in hours during which the system is removed from service for planned outages, such as scheduled overhaul or inspection.

a3. "Forced Outage Hours," FOH = the time in hours during which, due to the occurrence of a component failure or system condition, each WFGD system is not capable of achieving outlet SO_2 guarantee at the DISTRICT's required capacity over the specified range of loads and SO_2 content. The DISTRICT reserves the right to remove component(s) or the system from operation for reasons of safety or unusual maintenance or operation.

a4. "Period Hours," PH = the clock hours in the period under consideration, e.g., 8,760 hours for one year, 730 hours for one month, etc.

b. "Equivalent Availability Guarantee Period": A 12-month or longer period starting upon completion and DISTRICT acceptance of the first performance test (Performance Test A) of the system, used to demonstrate system reliability. The test period concludes with the successful completion of Test B.

c. Upon successful completion of Test A the systems and facilities included in the scope of work contained herein shall operate for a period of twelve (12) months (Equivalent Availability Guarantee Period), during which time the equivalent availability factor (EAF) shall be a minimum of 99.5%. If during any single month, the EAF is less than 99.5%, that month shall not be credited to the required 12-month period, and the Equivalent Availability Guarantee Period shall be extended one month. A

maximum of three-one month extensions will be allowed for a maximum period of 15 months, to show compliance with the 12 month Availability Guarantee. During the equivalent availability period for each unit, all costs for operating labor, power, water, and reagent will be borne by the DISTRICT. Disposition of gypsum will be by the DISTRICT. All costs for non-routine repair work and Equipment removal, modification and replacement shall be by CONTRACTOR. The cost of installing, maintaining and operating monitoring Equipment for verification of equivalent availability, excluding the DISTRICT's Continuous Emission Rate Monitoring (CEM) Systems, shall be by CONTRACTOR.

d. During this period, the systems and facilities included in the scope of work contained herein shall meet the SO_2 emission guarantee on a 30-day weighted rolling average as determined by new Continuous Emission Monitors (CEM) supplied by DISTRICT for the new chimneys/liners.

e. The systems and facilities included in the scope of work contained herein shall not limit the required unit load for any load between minimum load and URGE load during the Equivalent Availability Guarantee Period. Emissions acceptability shall be based on average stack emissions and the calculated average SO_2 removal efficiency on a 30-day weighted rolling average.

f. A total time period of 15 months will be provided to achieve the 12-month Equivalent Availability Guarantee demonstration run. If more than 4 months of less than 99.5% EAF occur during this 15-month period, the best 12-month EAF values shall be averaged on a time weighted basis to determine compliance with the 99.5% EAF Guarantee. Should the average EAF be less than 99.5%, the Liquidated Damages shall be implemented to complete the Equivalent Availability Guarantee Period.

104.17. Noise: CONTRACTOR shall guarantee that sound pressure levels for individual equipment will not exceed 85 dBA at 3 feet from the equipment and 5 feet above grade, or other standard platform elevation, under free field conditions above a reflective plane, when measured in accordance with ANSI Standard S1.13.

104.18. Guarantee Performance Tests

a. An Independent Third Party will conduct two performance tests: Performance Test A will be conducted on each WFGD system within 30 days after CONTRACTOR has finished tuning and turned the system over to the DISTRICT and performance Test B will be conducted on each WFGD system within 30 days after completion of the Equivalent Availability Guarantee Period. The Independent Third Party will conduct performance tests on the first WFGD system to come online, reagent preparation system, and dewatering systems separately from the second WFGD system to come online to demonstrate compliance with all performance guarantees. Testing of the reagent preparation and dewatering systems will be conducted with the first WFGD system test.

b. Each performance test will be conducted at the DISTRICT's expense (with the exception of the noise tests), including installation of the Independent Third Party -supplied temporary test equipment. The test protocol guidelines, including test conditions, test procedures, and analytical methods for determining system performance and guarantees including emissions, are provided herein. A comprehensive performance test protocol shall be developed by the DISTRICT based on these guidelines. The Independent Third Party testing company retained by the DISTRICT will conduct all performance guarantee tests.

c. Guarantee testing will be conducted as near to URGE load as possible and while firing a coal as near to the design coal as reasonably possible.

d. The DISTRICT will operate the equipment to be tested at as near performance conditions as specified herein, as reasonably possible, while burning fuel as close to design fuels as reasonably possible. These operating conditions will be maintained for at least 4 hours prior to starting each test. Also, operating conditions prior to this testing period should be reasonably similar and stable. CONTRACTOR shall provide correction curves and equations for adjusting the performance at tested conditions to the design conditions. System inlet gas sampling will be at the inlet(s) of the CONTRACTOR's equipment. The CONTRACTOR, in accordance with the requirements of EPA Method 1, shall provide sample ports (with appropriate access) in the ductwork upstream of the CONTRACTOR's absorber inlet. Sample ports shall also be provided by CONTRACTOR in the absorber outlet ductwork for pressure drop testing as appropriate. System outlet gas sampling (SO_2, particulate, etc.) shall be at the DISTRICT's sampling location in the stack.

e. A minimum of six test runs will be conducted over a 48-hour period to demonstrate the performance guarantees for each of the two performance tests. Test runs will be performed with simultaneous sampling at all locations for each of the test runs. Each test run will be a minimum of two (2) hours in duration.

f. During the 48-hour test period, the WFGD system shall operate without operational use of the spare recycle pump; however, CONTRACTOR will be able to change operating recycle pumps as required.

g. To the extent practical, the performance tests will be run in accordance with the latest editions of the ASME PTC4.3 and EPA Methods 1 through 4, 5, 6C 30B, and 202 in Code of Federal Regulations (CFR) Title 40, Part 60, Appendix A (40 CFR 60 Appendix A). Additionally, EPA conditional test method 13 (CTM-013) will be used.

h. EPA Method 1 will be used to determine number and location of sampling traverse points for both particulate and sulfur dioxide sampling.

i. Particulate sampling will be conducted at the fabric filter outlet and at the stack location. EPA Method 5 will be used for filterable particulate sampling and analysis with the following exception: the probe filter temperature will be set at 320°F during sampling. EPA Method 202 will be used for condensable particulate sampling and analysis, as published in the federal register in December 2010 or later. Sampling will be for a minimum of three minutes per point; however, each test run will be at least two (2) hours in duration. Mist eliminator carryover will be determined/confirmed during scale model testing.

j. An integrated multi-point sample for flue gas analysis according to EPA Method 3A will be obtained at each test station for each test run.

k. Fuel samples will be taken by the DISTRICT. The sample will be taken at such a time as to ensure that it will be a representative sample of the fuel to be burned during the test. The DISTRICT will divide the sample into two equal parts. The DISTRICT will be responsible for the sample analysis which will be conducted in accordance with the latest edition of ASTM D3176, D3172, and D5865. One sample will be analyzed by the Independent Third Party per the above while the second will be held by DISTRICT for future use if required by CONTRACTOR.

l. Gas flow rate to the WFGD system will be calculated using ASME PTC4.3 with the ultimate analysis of the fuel, the fuel feed rate, and the analysis of the gas at the WFGD system inlet. The gas flow rate obtained by the Pitot tube method will be calculated for each location and recorded in the final report for information only. DISTRICT will obtain the necessary data for ASME PTC4.3 during the performance test. The gas flow rate determined through the use of ASME PTC4.3 (stoichiometric)

will be used to determine the amount of gas being treated by each WFGD system for comparison to the design flow rate.

m. Guaranteed removal efficiencies will be calculated from the absorber inlet value and the stack value for each test run. The average of the results from the six test runs will be used to compare with the contract guarantee.

n. Oxidized mercury removal will be determined by EPA method 30B using speciated traps.

o. SO_3 removal and emission shall be determined using the procedure described by the controlled condensation method, EPA CTM-013.

p. HCl removal and emission shall be determined using the procedure described by EPA Method 26 or 26A.

q. Ball Mill Performance Test – Samples of limestone product from the ball mill will be obtained by the DISTRICT and analyzed by the Independent Third Party to confirm that the desired product is being obtained at the rated capacity. The method for analyzing particle size will be EPRI Method G1 and the method for determining slurry density to be used in the capacity calculation is EPRI Method D2. Similar analytical methods may be used that are mutually agreeable equivalents. Ball mill capacity will be determined by the time required to fill the tank with limestone slurry that meets the specified particle size while not withdrawing slurry from the tank.

r. Two one-quart samples of limestone slurry will be taken using EPRI Method A1 by the DISTRICT while filling the fresh limestone slurry tanks with slurry prior to the testing. One sample of limestone slurry will be retained by CONTRACTOR for future analysis, if required. The other sample will be analyzed by the Independent Third Party for total alkalinity using Method N3 and total calcium and total magnesium using Method J3 from the referenced EPRI manual and the other held for future analysis if required. Two one-quart samples of raw limestone will be taken from the gravimetric feeder discharge. One sample will be analyzed using Method B7 test procedure to determine moles of available alkalinity, while the other sample will be retained by CONTRACTOR for future analysis, if necessary.

s. Two one-quart samples of gypsum slurry will be taken by DISTRICT from the belt filter feed during each of the test runs. One sample will be analyzed by the Independent Third Party using the Electric Power Research Institute's (EPRI) FGD Chemistry and Analytical Methods CS-3612. These samples will be filtered and washed with a gypsum solution to remove adherent liquor and dried in an oven at 50 deg C. This will minimize the effect of chlorides on the stoichiometric ratio analysis. The dried solids will be analyzed using the following methods: Method J3 shall be used to determine total calcium and total magnesium; Method L2 for sulfate and Method M2 for sulfite. The second sample will be retained by the CONTRACTOR for future analysis, if required.

t. The value (average of 6 runs) for limestone stoichiometry will be compared to the guarantee value for demonstration of the system guarantee. The limestone stoichiometry will be calculated from a sample of gypsum and limestone slurry as follows:

$$S_R = \left(\frac{(\text{Moles of Ca} + \text{Moles of Mg})}{(\text{Moles of sulfite} + \text{Moles of sulfate})} \right) \times \left(\frac{\text{Moles of available alkalinity}}{(\text{Moles of Ca} + \text{Moles of Mg})} \right)$$

u. The limestone consumption rate will be calculated using the limestone analysis and EPA Method 6C results as follows:

$$\text{Consumption Rate} = \left[S_R \times \frac{\text{Pounds of Limestone}}{\text{Moles of available alkalinity}} \times \frac{\text{Moles of } SO_2 \text{ removed}}{\text{Hour}} \right]$$

v. Static pressure, velocity pressure, and barometric pressure for compliance with the system gas-side pressure loss guarantee will be measured by the Independent Third Party in accordance with ASME PTC19.2 (Chapter 3) and EPA Method 2.

w. Oxidation level: results for Method L2 for sulfate and Method M2 for sulfite will be used to determine the oxidation level.

x. Test equipment, calibration of test equipment, and sampling procedures will comply with Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. III, Stationary Source Specific Methods; EPA 600/4-77-027b and CFR 40, Parts 53-80, July 1, 1980; and the appropriate ASME and ASTM procedures.

y. All references to the American Society for Testing and Materials (ASTM) Standard Specification, American Society of Mechanical Engineers (ASME), EPA reference methods, and other standard publications are to the latest issue of each as of the date of this Specification unless specifically stated otherwise.

z. Total power consumption for the equipment supplied with this contract will be determined through the use of watt-hour meters. The watt-hour meters used will be connected at the power supply inputs to CONTRACTOR's equipment. Watt-hour meters will be accurate to within 0.3 percent. Power consumption tests will be conducted by the Independent Third Party over a period of at least 8 hours to measure average power requirements for the equipment when the boiler unit and WFGD system are operating normally at URGE load. The power consumption test will be conducted with one ball mill operating at guaranteed capacity. If the ball mill cannot be operated at this capacity for the full 8 hour test, the reduced average power consumption of the ball mill will be adjusted to an 8 hour average.

aa. Power consumption guarantee for the equipment does not include non-process loads such as lighting, HVAC, heat tracing, and welding/power receptacles, etc. Watt-meters will be minimized wherever possible.

aa1. Each piece of rotating equipment supplied under this contract shall undergo a noise test in a free-field environment with results showing the average noise level is less than the guaranteed value. CONTRACTOR shall be responsible for the cost of the noise tests. The CONTRACTOR shall notify the DISTRICT a minimum of 14 days prior to conducting the noise tests, and shall allow a representative of the DISTRICT to witness the noise tests.

104.19. CONTRACTOR shall provide correction curves and the corresponding mathematical equations for the curves to be used in evaluating the results of the performance testing. These curves shall be used to determine compliance with contract guarantees at the guarantee conditions if they are not achievable during the performance test. These curves shall include as a minimum the following relationships:

a. SO_2 removal efficiency vs. fuel sulfur content (0.5, 1, 1.5, 2, and 3 lb/mm Btu sulfur coal).

b. SO_2 removal efficiency vs. inlet SO_2 concentration in the flue gas.

c. SO_2 removal efficiency vs. absorber gas flow.

d. Limestone consumption rate vs. SO_2 removal efficiency with varying sulfur content coal.

e. Gas-side system pressure loss vs. measured gas flow.

105. FLOW MODEL TEST

105.1. Flow Model Test: For each unit one flow model shall be constructed. Identical model sections may be re-used for the second model constructed. CONTRACTOR shall construct a three-dimensional, clear, Plexiglas scale model of the system from the DISTRICT's existing induced draft fan outlet to and including the chimney liner elbow through the breeching and to the CEMS level. A 1/12-scale model shall be the minimum size used for the flow model test. Absorbers and absorber internals shall be included in the flow model. Internal members 4" in diameter and greater shall be included in the model. Consulting Engineer will submit ductwork design and routing to CONTRACTOR as input for the flow model. If the existing ductwork needs to be modified to be compatible with CONTRACTOR's design, CONTRACTOR shall describe the alteration for Consulting Engineer's review and detailed design. CONTRACTOR's passing any performance criteria within the flow model test does not supersede the requirement to meet any and all performance guarantees for the full scale system as defined by the performance testing section.

105.2. The objectives of the flow model test shall include the items listed below.

a. Provide satisfactory distribution of flue gas within the absorber, immediately upstream of the mist eliminator and downstream of the mist eliminator such that the RMS flow value at any location does not deviate from the mean flow by more than ± 15%. Gas and liquid flow model test data shall be submitted for CONTRACTOR's absorber design to indicate that satisfactory flow distribution is achieved at all operating conditions.

b. Provide satisfactory distribution of flue gas at the WFGD inlet such that the RMS flow value at any location does not deviate from the mean flow by more than ± 15% with no areas of reverse flow. Gas and liquid flow model test data shall be submitted for CONTRACTOR's absorber design to indicate that satisfactory flow distribution is achieved at all operating conditions.

c. Recommend location and configuration of turning vanes and moisture removal devices for CONTRACTOR's ductwork and chimney liners where practical to minimize pressure drop and maximize entrained water collection during URGE load and partial load operation.

d. Recommend location and configuration of turning vanes in ductwork upstream of the absorber to minimize pressure drop and ash drop out, and to meet the booster fan manufacturer's recommended inlet and discharge flow profiles.

e. Obtain a measurement of system pressure losses for use in confirming the final sizing of the DISTRICT's induced draft booster fans.

f. The mist eliminator element testing shall confirm that the mist eliminator system design provided by CONTRACTOR shall achieve a moisture droplet carryover less than or equal to 0.070 grains per standard cubic foot of flue gas flow using a Phase Doppler Particle Analyzer (PDPA).

g. Determine the recommended location of sampling ports in the ductwork upstream and downstream of the WFGD system. Sampling ports shall preferably be located on top of the duct and shall clear any turning vanes present in the ductwork.

h. Recommend location and configuration of liquid removal devices. The chimney model tests shall determine where the wet gas impinges on the chimney liners under various operating conditions. The model test firm shall make recommendations on the location and design of liquid collectors and drain systems within the DISTRICT's chimney.

i. The principal objective of the wet stack flow modeling is to configure liquid collection devices that minimize entrainment of droplets that are either carried-over from the mist eliminators or that are formed by condensation on the duct and chimney liner walls.

j. The chimney flow modeling shall be performed at an average test velocity pressure (velocity head) corresponding to the velocity pressure at the full-scale maximum flow condition.

k. The flow model shall demonstrate by flow visualization that droplets that collect on the liner surfaces fall downward or are pulled upward to a collection device. The flow model shall also demonstrate that liquid, once collected in the gutters, flows to the low point without re-entrainment.

105.3. After construction of the flow model, CONTRACTOR shall perform a preliminary flow model test to indicate obvious trouble areas. Locate gas distribution devices as required until velocity and flow distribution appears satisfactory.

a. Determine preliminary locations for gas distribution devices within the absorber to avoid any gas bypass or "sneakage."

b. Determine the coverage area by the spray headers designed for the application. The coverage by individual spray header shall exceed 150% and combined coverage shall be 150%.

b1. After preliminary location of all distribution devices has been made, obtain velocity data and perform statistical analysis to verify that velocity is as specified. If flow profile is not satisfactory, adjust gas distribution devices as required until a uniform flow is obtained. The outlet elbow/cone of the FGD shall also be modeled in both the original configuration and the 90 degree rotated configuration to ensure that there is no impact to performance of the wet FGD absorber. The final shape of the duct shall be carefully chosen based on the flow model testing.

c. After uniform flow is achieved, perform dropout testing to determine potential areas of gypsum, fly ash and/or mist eliminator carryover solids accumulation. Tests shall be made at URGE load and minimum load.

d. All potential buildup areas should be swept clean. If additional vaning is required to minimize dropout, obtain velocity distributions and statistically analyze to verify that satisfactory flow distribution is maintained.

e. CONTRACTOR shall advise the DISTRICT of any requirements, changes in design or other pertinent information required to provide suitable gas flow and distribution. Requested alterations shall be made by CONTRACTOR in the model to demonstrate the effect of such changes or modifications. CONTRACTOR's turning and guide vane design will be reviewed by Others. If necessary, CONTRACTOR shall make the changes required to the turning and guide vane design to provide acceptable flow patterns for the CONTRACTOR's equipment and equipment by Others. CONTRACTOR shall keep the model assembled and ready for further testing until comments by the DISTRICT on the flow model study report are resolved.

f. Perform system pressure drop tests at the specified maximum continuous gas volume.

105.4. CONTRACTOR shall arrange for DISTRICT's witness test where all requirements in the specification for the model are demonstrated to the DISTRICT's representative. Two weeks prior to witness testing, CONTRACTOR shall submit a draft of the flow model report for DISTRICT's review (draft report may be electronic).

105.5. Flow Model Study Report:

a. CONTRACTOR shall discuss the following items as a minimum in the formal flow model study report:

a1. Extent, procedure, and conclusions of the flow model test and how the stated objectives were achieved

a2. Development of flow model parameters including an explanation of the theory and method used to correlate the model velocity and pressure measurements to the full size system

a3. Effect of various turning vane arrangements on gas distribution and pressure loss.

a4. Duct drawings with location of turning vanes, perforated plates and sample locations corresponding to each run reported.

a5. Graphs of horizontal and vertical velocity profiles at various locations in the ductwork, at the absorber inlet, mist eliminator outlet, and chimney liner.

a6. Recommendations on the location of flow distribution devices within the WFGD system

a7. Recommendations on the location and configuration of turning vanes in the DISTRICT's inlet ductwork

a8. Recommendations on chimney liquid collectors and drain system within the DISTRICT's chimney and chimney breeching duct.

a9. Any flow obstruction in the DISTRICT's ductwork, no matter how minor, which CONTRACTOR elects not to model, shall not be used as a basis for claims of poor distribution in the actual installation and shall not be used as a basis for not meeting performance guarantees.

105.6. Flow model study and report shall be completed prior to the fabrication of CONTRACTOR's absorber or ductwork and shall be submitted to the DISTRICT and Engineer. The CONTRACTOR shall include all model data in electronic form and in the report.

105.7. CONTRACTOR shall store the flow model for a minimum of one year after the initial gas flow through the second full size system to come on-line. The DISTRICT shall have an option to receive the flow model prior to disposal.

PART 2 – PRODUCTS

201. DESIGN & FABRICATION

201.1. Absorber

a. Each unit shall have a single (100% URGE load) absorber module. The absorber module shall contain N+1 contact or spray stages, where N is the number of contact stages to obtain guaranteed performance without additives. The N+1 stage shall be considered a spare stage and shall be complete with installed pump, automatic valves, and all other appurtenances.

b. Either the use of open spray tower design or the use of mass transfer trays are acceptable provided CONTRACTOR has at least 3 absorbers operating with trays on PRB coal and meeting over 95% SO_2 removal.

c. The maximum superficial gas velocity shall be 14 ft/s based on the full inside diameter of the absorber and the design saturated gas volumetric flow rate at URGE load.

d. The nominal minimum absorber slurry flow (L/G) for spray tower design shall be 110 gallons per 1,000 actual cubic feet of fully saturated flue gas for the design gas flows specified. For a tray tower design, the nominal minimum absorber slurry flow shall be 75 gallons per 1,000 actual cubic feet of fully saturated flue gas.

e. The CONTRACTOR shall determine the number of spray nozzles per stage or equivalent pertaining to the CONTRACTOR's specific absorber design. The spray nozzles shall be arranged to achieve uniform slurry flow distribution and 150% complete coverage of the absorber cross-section at a point three feet below the spray nozzles. Nozzles and spray headers shall be staggered in each spray level to afford complete coverage across the absorber cross-section. Care shall be taken to avoid erosion on vessel walls and lower internals due to slurry impingement. Extra erosion allowance and wear plates must be provided for areas of impingement. Spray nozzles shall be attached to the internal headers using a bolted design. Plugging of a single nozzle shall not allow flue gas to pas through the absorber without sufficient slurry contact.

f. The absorber building shall enclose the oxidation air compressors, recycle pumps, recycle tank agitators, hydroclones, hydroclone underflow pumps, mist eliminator wash tank and pumps, bleed pumps, and emergency quench pumps.

g. Materials:

g1. The absorbers will be exposed to fluorides, chlorides, sulfur dioxide, sulfuric acid, sulfurous acid, water, ammonia slip and other corrosive constituents. The absorber will also be exposed to temperature variations, vibration, surface impingement and intermittent wet/dry conditions (especially at the flue gas inlet to the absorber). The absorber shall be designed to minimize crevices subject to corrosion, slurry solids buildup, scaling, general corrosion, pitting attack, stress corrosion, vibration and other potential problems. All attachments to the inside of the absorber shall be designed such that no crevices remain. Faying surfaces, i.e. metal to metal contact areas, shall be designed to allow fillet welds on all sides.

g2. CONTRACTOR shall recommend the appropriate materials of construction for the expected operating conditions and all vessel parts and storage tank internals subject to corrosive or erosive conditions shall be made of materials especially suitable to withstand such conditions. The absorber and all other system materials shall be capable of withstanding chloride concentrations of up to 30,000 ppm. Except where noted otherwise herein, the wetted surfaces of the absorber vessels shall be a minimum of stainless steel, alloy, tile-lined concrete or lined carbon steel.

g3. The wet/dry interface and the first 10 feet of inlet duct shall be solid alloy C-276 material (UNS# N10276) and shall be designed to angle downward into the absorber.

g4. The integral recycle tank shall be the same material as the rest of the absorber. CONTRACTOR shall provide a vinyl-ester coating or equivalent to protect the base metal from maintenance activities (such as cleaning out solids with a carbon steel shovel). The coating shall cover the floor and a 3' height of the tank walls.

g5. The absorber wetted surfaces starting at the mist eliminator supports and beyond, including absorber top, cone, elbow, and duct to chimney breech, will experience lower pH than surfaces below. CONTRACTOR shall install materials that are suitable for the low pH environment. These surfaces shall be FRP or clad C-276. DISTRICT will consider other materials as an option.

g6. Metal surfaces for all CONTRACTOR supplied vessels and tanks shall be abrasive blasted in the shop to remove mill scale. Absorber and tank bottoms shall be welded or tile-lined. All vessels shall be

designed in accordance with ASTM 4618-92 as well as all other codes and standards listed in this Specification.

g7. Absorber wetted internals such oxidation air lances and supports, stiffeners, nut and bolts, spray piping and pipe supports, support grid below the first spray level, and mist eliminator piping and supports and holding rods, etc., shall be constructed of corrosion-resistant alloy material or FRP.

g8. The external stiffeners for the absorber and outlet ductwork shall be compatible with the base absorber material. If the absorber is stainless or alloy, the stiffeners shall be stainless steel at a minimum.

g9. All tools (grinders, brushes) used on interior metal surfaces shall be a material compatible with the base metal. All welds shall use filler materials that are of equal or greater corrosion resistance.

h. The absorber module shall be constructed to form a watertight and gastight envelope from the module inlet to the module outlet. Any penetrations of the module shell required for piping connections or accessories shall be sealed to keep the module leaktight.

i. All internal piping, floors, trays, and gratings within the absorbers including the mist eliminators shall be designed for a minimum live load of 100 psf, in addition to dead load and construction loads, and shall be fabricated of corrosion- and erosion- resistant material.

j. Absorber modules shall be freestanding. The module shall be designed to accommodate pressure and vacuum loads, piping forces and moments, environmental conditions, seismic conditions, and all other loads imposed on the module. Reinforcement or bracing shall be adequate to minimize module shell vibration resulting from any condition, which possibly could occur within the absorber or ductwork.

k. The welding process to be used for welding alloy materials of construction should contribute low heat input, good fusion and produce smooth finish weld surfaces. GMAW pulsed arc is recommended with appropriate welding materials. Materials containing chloride or other constituents capable of inducing stress corrosion in stainless steel are prohibited. CONTRACTOR shall take extra precautions in handling alloy materials.

l. Weld Seams For Vessels: All interior weld seams shall be free from surface defects including weld slag, weld splatter, overlap, undercut, pinholes, sharp edges, and other such conditions which could interfere with the coating system adherence. All weld interior seams shall be ground smooth and blended in accordance with NACE RP0178-2003 "Fabrication Details, Surface Finish Requirements and Proper Design Considerations for Tanks and Vessels to be Lined For Immersion Service", Weld Preparation Designation C or better.

m. Access Doors: Heavy-duty, quick opening davit style, leakproof 36"x 36" (minimum size) access doors shall be provided at grade, tray and spray levels, mist eliminator, mist eliminator wash spray levels and all other areas where access for inspection and maintenance is required. The access doors for the absorbers shall be constructed of the same material as the absorber or higher. Doors shall be provided with external latches and tightening devices, which allow for gasket shrinkage and still maintain zero leakage. Doors shall be provided with means to lock in the open position to prevent accidental closing with maintenance personnel inside. Provisions shall be included inside the absorber vessel to facilitate the installation of maintenance platforms and scaffolding for access to absorber internals.

n. Spray nozzles shall be connected to the spray headers with bolted flanged fittings for easy removal and installation. Victaulic couplings are not acceptable.

o. Spray nozzles shall be constructed of silicon carbide.

p. External spray piping shall be constructed of FRP.

q. The piping shall be designed to minimize internal plugging and external solids buildup and scaling. Internal piping including branches off of main header shall be installed with flanges so all sections can be removed and replaced through the tower/tank openings.

r. The piping shall be suitably reinforced to minimize vibration.

s. Rod out connections shall be provided for each spray header branch line.

t. The absorber shall include provisions for the installation of insulation and lagging, as required. Furnishing and installation of insulation and lagging will be by the CONTRACTOR.

u. WFGD Access and Equipment Support Structure:

u1. Design, furnishing, and erection of the WFGD access and equipment support structure shall be by the CONTRACTOR.

201.2. Absorber Integral Oxidation Recycle Tank and Miscellaneous Appurtenant Equipment

a. The capacity of the absorber recycle tank shall provide adequate retention time to facilitate crystallization in the tanks to prevent detrimental scaling and plugging in the absorber. The system shall efficiently and thoroughly utilize limestone to a very low stoichiometric (Ca/S) ratio. The tank shall be sized to provide a minimum of 15 hours of solids retention time based on the design absorber bleed flow rate and 6 minutes of liquid retention time based on the absorber recycle rate of N stages operating.

b. CONTRACTOR shall provide oxidation air compressors as specified herein for oxidation of sulfite to sulfate in the recycle tank. A spare will be provided for each absorber. Oxidation air compressor equipment design shall be per Section 431250.

c. The minimum oxidation air stoichiometry (O/SO_2 removed) shall be 2.0. CONTRACTOR shall provide a minimum slurry depth of 25 feet above the injection points.

d. Air spargers provided with tank shall be of the lance type. Air spargers shall be structurally sound with minimum vertical and horizontal movement under tank operating conditions. They shall be suitably placed so as not to interfere with agitators and pump suction connections.

e. CONTRACTOR shall provide lances, piping, valves, etc. that are required for the forced oxidation process. The internals, piping and supports shall be corrosion-resistant alloy.

f. Humidification of the oxidation air shall be provided using make-up water to saturate the air and prevent scale formation at the sparger lance air/slurry interface.

g. A minimum 10 ft wide x 12 ft high door shall be included in each recycle tank for maintenance access for a small front end loader. The design of each absorber shall include steel and reinforcing required for attaching CONTRACTOR'S door removal hoist system.

h. Absorber Agitators:

h1. Integral absorber recycle tank shall be equipped with side-mounted agitators. The number of agitators and agitator arrangement shall be selected to be capable of suspending the solids in the tank with one agitator out of service. Absorber recycle tank agitators shall be located so as not to damage other equipment and sized to prevent solids accumulations greater than 0.5% of the tank volume.

h2. Agitators shall be a turbine or marine type design by acceptable suppliers defined in this Specification.

h3. Absorber agitator locations shall be determined from a fluid model study to prevent pump cavitation and to minimize solids accumulation on the tank bottom and to re-suspend solids after 24 hours without agitation. Water lance(s) shall be provided at each agitator to remove material accumulation and allow the agitator to be placed back in service. An approximate one-twelfth (1/12) scale model of the recycle tank for each unit shall be constructed and tests shall be conducted to establish compliance with the following requirements:

h3.1 Be designed so that failure of any one agitator shall not be a reason for reduced capacity or reduced performance of the WFGD system and shall not cause blockage of pump suction.

h3.2 Accomplish the dispersion/mass transfer of oxidation air to the absorber slurry.

h3.3 Prevent oxidation air from entering the suction lines of the pumps.

h4. The agitators shall be provided with replaceable split seal cartridges. The seals shall be replaceable without draining the contents of the tank.

201.3. The CONTRACTOR shall provide the absorber recycle and bleed pumps, pump suction & discharge piping, valves and associated instrumentation and control. Construction shall be suitable for slurry service and in accordance with the requirements specified herein.

201.4. Mist Eliminators

a. The absorber shall be equipped with two vertical-flow, mist eliminators and all required structural supports. The mist eliminators shall be located in the upper portion of the absorber. The mist eliminator shall include a scalping or bulk liquid entrainment separator in the lower section and a high efficiency upper section.

b. Top- and bottom-wash piping and sprays shall be provided for the first stage and bottom-wash piping and sprays for the second stage. The mist eliminators shall be designed to collect entrained water droplets and particulate matter during all modes of absorber operation, including mist eliminator washing.

c. The lowest mist eliminator level shall be a minimum of 6 feet above the highest absorber spray bank.

d. The mist eliminator shall be constructed in sections that are removable through the absorber access doors.

e. The top of the mist eliminator shall be a minimum of 3 feet below the bottom of the absorber outlet cone. The minimum separation distance between mist eliminator stages shall be 6 feet.

f. The mist eliminators shall not be stressed beyond 95% of their yield stress during the temperature transients that may occur due to loss of recirculating slurry flow and/or mist eliminator wash water flow.

g. The mist eliminator shall be designed to minimize pressure drop with minimum solids build-up and with maximum face velocity of 14 ft/s, based on saturated flue gas, for horizontal orientations (vertical upward gas flow). Horizontal flow mist eliminators shall have a maximum face velocity of 30 ft/sec.

h. Mist eliminator washing shall be sectioned and timed to minimize negative chemistry impacts to the absorber recycle tank. The minimum instantaneous mist eliminator wash rate shall be 1.5 gpm/ft^2 on the front face of the first stage and 0.6 gpm/ft^2 on the back face of the first stage and front face of the

second stage. The spray pattern shall be full cone with no more than a 90-degree spray angle. The CONTRACTOR shall include provisions for continuously monitoring the mist eliminator wash rates for each section and at the front face of the first stage, back face of the first stage and front face of the second stage.

i. CONTRACTOR shall design the mist eliminator for no gas "sneak by" between the support rim and the absorber wall or between any of the mist eliminator sections. Mist eliminator sections shall be suitably restrained to prevent sections from lifting and allowing gas to bypass the mist eliminator.

j. CONTRACTOR shall include provisions for continuously monitoring pressure drop across each mist eliminator stage.

k. CONTRACTOR shall include in the spare parts list the recommended spare mist eliminator elements for each stage of the absorber module for the DISTRICT's spare parts inventory.

l. The WFGD system shall use makeup water for mist eliminator washing from the CONTRACTOR's mist eliminator wash water tank.

201.5. The CONTRACTOR shall furnish the mist eliminator wash water tank, pumps, wash headers and piping, nozzles and associated instrumentation and controls required for this project.

201.6. Emergency Quench Systems

a. CONTRACTOR shall furnish all necessary equipment including two 100% capacity diesel driven pumps, piping and nozzles to provide a complete and operable emergency quench water system per absorber. The emergency quench systems shall be designed to reduce flue gas temperature to protect downstream equipment, such as the absorber, mist eliminators, ducts and the chimney liners, in the event of a station blackout, largest single air heater out of service, recycle pumps out of service, or any condition that results in high flue gas temperature in the absorber. The systems shall be designed to be single failure proof and be capable of automatic or manual initiation and with manual or low supply water tank level stopping.

b. It is CONTRACTOR's responsibility to determine the appropriate emergency quench water flow rate and duration to prevent damage to the WFGD system internals and chimney liners.

c. The system shall quench the flue gas and maintain an absorber temperature of no more than 180°F.

d. CONTRACTOR shall provide and install at least 3 temperature sensors that will initiate the quench system.

e. Quench system shall have a manual test mode so that the DISTRICT can test the quench once per month to verify its availability for operations.

f. The DISTRICT will provide fire protection water as the normal supply of water for the emergency quench systems.

g. The CONTRACTOR shall provide tanks for storage of a backup supply of quench water. The tank can be dedicated to the quench system or serve dual purposes such as a reservoir for quench water and either mist eliminator wash water or makeup water or reclaim water. The tank shall be sized to supply quench water for at least 30 minutes.

h. Unit 1 and 2 operating data has been provided for events that could require quench water such as Station blackout or loss of the largest air heater drive. If other data is needed, it should be requested before the bid is due.

201.7. Reagent Storage and Preparation

a. CONTRACTOR's limestone preparation facilities shall consist of, but not be limited to, the following: limestone silo(s), gravimetric feeder(s), ball mill pulverizer(s), mill product tank(s), mill product transfer pumps, limestone classification system, particle size analyzer, covered limestone slurry storage tanks, reagent feed pumps, all interconnecting piping, valves and other appurtenances and associated instrumentation and control. Limestone silos, discharge chutes and shutoff gates to gravimetric feeders shall be provided by the CONTRACTOR.

b. The limestone supply system shall supply 30-wt% solids slurry capable of passing 95% through 325 mesh.

c. The reagent preparation building shall enclose limestone silos, ball mills, classifiers, mill product tanks and transfer pumps, limestone slurry storage tanks and limestone slurry pumps.

201.8. Limestone Storage Silos:

a. CONTRACTOR shall provide two welded steel silos, each capable of storing 24 hours of limestone for the Station (two units). The storage silos shall be complete with structural steel supports, silo bottom plate, steel framing for operating floor, and enclosures for operating floor.

b. Each silo shall be equipped with one discharge hopper. Silo discharge hopper valley angles shall be a minimum of 70 degrees to the horizontal unless the limestone flow test results require a steeper valley angle.

c. Each silo hopper shall have two suitable vertical faced pounding lugs or sledgehammer strike plates on opposite sides. Strike plates shall have a vertical impact face and shall extend 1 foot horizontally from the wall. CONTRACTOR's design shall provide adequate access to the strike plates.

d. Each silo shall include a silo live bottom to provide uniform flow at the discharge.

e. Each silo hopper shall have two tilted four-inch-diameter poke holes fitted with hinged, gasketed dusttight caps and with personnel access.

f. Silo shall include at least one 24 x 36 inch roof manway (or manufacturer's nearest standard size).

201.9. Limestone Gravimetric Feeders:

a. CONTRACTOR shall furnish one limestone gravimetric belt feeder per ball mill capable of adjusting limestone feed from the limestone silo over the range of conditions the ball mill system is designed to operate.

b. CONTRACTOR shall provide feeders furnished complete with motor drive and controls. Feeders shall be capable of both forward and reverse operation. System shall be designed such that feed to the gravimetric feeders does not plug. This can be achieved through bin dischargers, adequately large inlets, and adequately steep feed chutes. Feeder bottom shall be designed with a sloped bottom and manually initiated, automatic flush to be self-cleaning into the weigh feeder discharge chute.

c. The feeder belt shall be two ply rubber with a "V" guide and 1.5 inch high curbs. A heavy drive pulley, self cleaning tail pulley, and automatic tension roll system shall be included to control belt tension. The belt drive shall be direct coupled through a gearbox and all bearings shall be greaseable from outside the feeder. The belt shall have a mechanical type splice to allow belt to be changed without removal of rollers.

d. The weighing system shall be dual cantilever type load cells, sealed to keep moisture out and be pressure insensitive. Calibration shall be accomplished by an integral internal weight system.

e. Feeder accuracy shall be ±0.5%.

f. The feeder shall be equipped with a tachometer indicating reagent feed rate. The tachometer shall indicate feed rate in tons per hour; the total integrator shall indicate reagent delivered over a period of time.

g. Feeder body shall have a 24 inch Type 304 stainless steel inlet collar to provide a 24 inch full width on the belt. The feeders shall have high center leveling bars to accept the specified limestone feed size.

h. Each feeder shall be fully enclosed and dust-tight with the housing extending down to the supporting floor on all sides. Housings shall be provided with suitable dust-tight access doors.

i. Electronic linear variable speed electric motor drive shall provide feed rate measuring feedback signal. Accessories shall include total feeder digital integrator and indicator, and separate freestanding NEMA 4X control cabinet to house motor starters, VFD speed controller, relay, etc., all wired to terminal strips. Motor starter, if required, shall be minimum of size 1. All feeder inputs and outputs shall be available to the WFGD DCS system.

j. Each feeder shall include an integral panel with "run-off-calibrate-jog" and “forward-reverse” selector switches and "on-off" pilot lights. Switches shall include nameplates and lockout.

k. Two paddle type reagent stoppage alarm switches shall be provided as an integral part of each feeder. One shall be located over the feed belt near the inlet to give immediate notification of absence of reagent at this point. One shall be provided at the feeder discharge to stop the feeder in event of flooding at that point.

l. A flow monitor shall be provided, consisting of a device which determines that the feeder belt is moving and, when used in conjunction with the paddle alarm over the feeder belt, will confirm that reagent is flowing.

m. All integral wiring for motors, illumination lights, alarms, etc., shall be provided. Feeders shall be provided with a conduit entry box having terminals for making necessary electrical connection to external power supply and control wires.

n. The feeder and feeder outlet hopper shall convey and feed reagent to the ball mill at a sufficiently uniform rate to produce satisfactory, pulsation-free operation and at such varying rates as required by load changes.

o. Feeder outlet hopper at the discharge end shall be constructed of 3/8-inch thick 304 stainless steel. Hopper height shall be sufficient to provide slope angles in the hopper body plates to ensure proper flow of material through the hopper. Hopper shall be welded inside and outside with internal seal welds ground smooth to eliminate any roughness that could contribute to material buildup. Inlet and outlet flanges shall be 3/4-inch thick stainless or mild steel. Appropriate hopper connections shall be provided for such functions as slurry re-circulation, water spray wash down, etc. Wear protection shall

be provided where ball loading and regrind line possibly could cause wear problems. Outlet hopper shall have bolt in replaceable liners. A dust-tight access door shall be provided.

p. CONTRACTOR shall provide the discharge chute with a dust tight access door at the tail pulley.

q. Each feeder part in contact with the reagent shall be constructed of Type 304 stainless steel.

201.10. Ball Mill Pulverizers:

a. CONTRACTOR shall furnish ball mills, designed for continuous operation, assume 2 units at URGE load while burning the design fuel. The limestone will be supplied as detailed in this Attachment 3.

b. Each ball mill shall meet a throughput capacity of 40 tons per hour with a product that passes 95% through 325 mesh.

c. Wet ball mills shall be horizontal and shall have alloy-capped rubber lifters, and rubber drum and head linings.

d. A local operated turning device or a jog pushbutton shall be furnished for each ball mill to facilitate spotting the door in the drum opposite the opening in the casing. The turning device shall attach to the open end of pinion gear to allow for work on air clutch and/or reducer when mill maintenance is in progress. Turning device shall be capable of turning mill in either direction.

e. A floor mounted force feed, lubrication system shall be furnished for each ball mill. The system shall be simple and shall not require shutdown for lubricant checking or addition. Heaters shall be provided if required. CONTRACTOR shall provide all instrumentation and control for the oil system. Additionally, the ball mill lube system shall include low-pressure permissive, filtration, sample port, portable filter connections, temperature and pressure indication, protection from wash down and redundant pumps with sufficient isolation to allow for the replacement of pumps and seals with the lube system in service.

f. Each ball mill shall be equipped with air clutch for start-up and shall be designed to withstand the stresses resulting from across-the-line starting motors.

g. CONTRACTOR shall provide ball mill vibration switches: One per driver and two per ball mill with a probe on each bearing.

h. Each ball mill shall be provided with spout, scoop, drum, or combination drum-scoop feeders with alloy or rubber linings.

i. Each ball mill discharge shall be provided with a trommel screen.

j. Each ball mill bearing shall be provided with thermocouples and ¼" NPT oil sample connection.

k. Each ball mill shall be provided with an independent ball charging system, an initial charge of balls, and a complete spare charge of largest size balls. A suitable monorail and hoist system shall be provided by the CONTRACTOR for loading balls into the mill. CONTRACTOR shall provide the system for charging balls into the mill.

l. Each ball mill shall be driven by a ring gear and pinion drive system. The pinion shall be supported on self-aligning, anti-friction roller bearings. The ring gear shall be 360° fully enclosed.

m. CONTRACTOR shall provide control logic and schematic diagrams detailing the ball mills and all other drive motors control. The controls shall be designed by the CONTRACTOR and interlocked so that the limestone feeder is stopped if the ball mill is inoperative.

n. Each ball mill shall be provided with a drum manhole for access for inspection, maintenance and/or cleanout.

o. Each ball mill shall include a distribution box that shall accept oversized particles from the classifiers and feed them to the pulverizers.

p. Each ball mill shall be furnished with a dust-tight NEMA 4X freestanding control cubicle with rear access, pre-wired to accommodate the WFGD DCS controls. This control station is for positioning the mill for maintenance only.

q. The motor drive provided shall start before the main motor drive is engaged. The motor drive provided shall be capable of starting the mill when the mill is fully loaded.

r. Each ball mill shall be provided with a 2-2 ½" minimum shop installed rubber drum liner. The liner shall be designed for ease of repair in the field.

201.11. Mill Product Tank(s) and Transfer Pumps

a. CONTRACTOR shall furnish mill product pumps for each mill product tank as herein specified. The pumps shall be capable of pumping the slurry from the mill product tank through the cyclone classifiers and to the slurry storage tank.

b. Pump design point shall be selected based on CONTRACTOR's recommended safety margins, but as a minimum, shall include a 5% margin applied to the flow and 10% applied to the head in the system curve calculations for two units at URGE load.

c. CONTRACTOR shall provide at grade (not a sump) covered, round mill product tanks, dedicated to collect the overflow from each ball mill including clean-outs, drains, man-ways, etc. The tanks shall be of adequate capacity to provide storage, NPSH, and a uniform concentration for the mill product tank pump feed to the classifiers. Tank capacity shall also be adequate to allow mill shutdown without spillage.

d. Agitators shall be provided as specified herein for the mill product tanks.

e. CONTRACTOR shall provide adequate mill product tank freeboard to prevent overflow based on the design ball mill wash rate.

f. CONTRACTOR shall provide density and flow indications for the mill product system.

g. The pipe used for limestone slurry from the product tank to the cyclone classifiers shall be rubber lined-carbon steel or FRP with abrasion resistant lining. The regrind line from the classifier to the ball mill shall be rubber lined. Limestone slurry piping from the classifiers to the limestone slurry storage tank and transfer piping shall be rubber lined carbon steel or FRP with abrasion resistant interior coating.

201.12. Cyclone Classifier

a. A cyclone classifier cluster including auxiliary support steel shall be provided for and dedicated to each ball mill to return oversized material back to the ball mill distribution box for regrinding. A

minimum of two manifolded spare cyclones or 25% spare cyclones, whichever is greater, shall be included in each cluster. The classifiers shall produce no coarser material than 95% through 325 mesh based on the mill design capacity and the design solids concentration feed rate to the classifiers.

b. Classifiers shall be lined with abrasion resistant ceramic including vortex finder and apex inserts. The lining shall be replaceable. The vortex finder and apex inserts shall be interchangeable with other sizes, and shall be selected such that one size larger and one size smaller sizes are available for performance adjustment and optimization.

c. The classifier shall have a particle size monitor to measure limestone fineness.

d. Classifiers shall be constructed of housing sections consisting of cast aluminum or carbon steel. Each classifier shall be of sectionalized design with replaceable ceramic liners.

e. The vortex finder on the classifier only shall be ceramic and available in multiple sizes for each classifier.

f. Feed and overflow connections shall be rubber lined and shall be either flanged or quick disconnect design.

g. Classifier manufacturer shall supply a manifold system, with classifiers, isolation valves, feed distributor, overflow and underflow collection launders, and structural steel support skid.

h. The manifold design shall permit convenient removal of any classifier without disturbing other classifiers for disassembling the manifold system. Blanked-off connections shall be provided for any unused classifier feed outlet pipes.

i. The classifiers shall be independently supported with no interference for vertical removal. Classifiers shall be mounted vertically for long-term convenience in accessing apex for adjustment or inspection or at an angle if required for the application. CONTRACTOR shall provide a written description as to the specifics of its removal system, access, galleries, etc.

j. The feed distributor shall be rubber lined.

k. A half nipple with isolation valve and a pressure gauge shall be located in the feed manifold dome for inspection by operators.

201.13. Limestone Slurry Storage Tank

a. CONTRACTOR shall provide limestone slurry storage tanks as herein specified. Each tank shall be sized to hold in its usable volume the total fresh slurry make-up requirement for both units for a 48-hour period with a minimum of 2 ft of freeboard. Slurry tanks shall also be designed to accommodate flush water from the slurry feed system. Each ball mill shall be capable of feeding either slurry storage tank. Slurry from the limestone slurry storage tanks shall be able to be transferred to either absorber vessel.

b. CONTRACTOR shall provide the required covered limestone slurry storage tanks, with construction as hereinafter specified, including top-mounted slurry agitator. CONTRACTOR shall provide a stairway and a gallery supported from the tank to provide access to the slurry storage tank agitator and any valves located on top of the tank.

c. The limestone slurry storage tanks shall be carbon steel with internal flake glass lining.

d. CONTRACTOR shall provide a drain line (with isolation valve) to the trench and/or sump. CONTRACTOR shall provide a 4 ft. wide by 3 ft. high cleanout drain to the sump for clean-out.

201.14. Maintenance Slurry Storage Tank

a. CONTRACTOR shall provide a maintenance slurry storage tank, including top-mounted slurry agitator. This tank shall be common to Units 1 and 2 and shall hold the entire contents of either Absorber's recycle tank. CONTRACTOR shall provide a stairway and a gallery supported from the tank to provide access to the maintenance slurry storage tank agitator and any valves located on top of the tank.

b. The maintenance slurry storage tanks shall be carbon steel prepared with internal flake glass lining.

c. CONTRACTOR shall provide a drain line (with isolation valve) to DISTRICT's trench/area sump. CONTRACTOR shall provide a 4 ft. wide by 3 ft. high cleanout drain to the sump for clean-out.

d. CONTRACTOR shall provide a system of permanent pumps, pipes and valves to drain the recycle tank into the maintenance slurry storage tank within a 24 hour period. CONTRACTOR shall provide a system of permanent pumps, pipes and valves to pump the stored slurry back to the absorber recycle tank.

201.15. Limestone Slurry Feed System

a. The design of the limestone slurry feed system (including the storage tanks) shall meet the following minimum requirements:

b. The discharge from the feed pumps shall feed a dual loop slurry feed piping system, one loop will be operational while the second loop is an on line spare. Each loop shall be capable of supplying 100 % of the slurry requirements for each absorber. The feed pumps' discharge arrangement shall be designed to safely allow each feed pump to feed each loop. CONTRACTOR shall provide the necessary manually initiated, automatic isolation, flush, drain valves, and flush and drain piping so that only the operating slurry feed pump supplies the operating slurry feed loop while isolating the non-operating pump and loop.

c. The dual slurry loop return line piping arrangement shall be designed to allow the slurry from each of the return lines to be safely returned to either of the slurry storage tanks. CONTRACTOR shall provide the necessary manually initiated, automatic isolation, flush, and drain valves so that only the operating return loop returns slurry back to the operating tank while isolating the non-operating loop and tank.

d. The pumps' suction and discharge piping arrangements shall also be designed to allow the contents of each slurry storage tank to be transferred to the other storage tank. CONTRACTOR shall provide the necessary manually initiated, automatic valves (including isolation, flush, and drain valves) to safely accomplish the transfer while isolating non-operating equipment, loop piping, etc.

e. The pumps' minimum flow recirculation system (if required) shall be designed to allow the recirculated slurry to be safely returned to the top of both tanks. CONTRACTOR shall provide the necessary manually initiated, automatic isolation, flush and drain valves to ensure that slurry is recirculated from the operating feed pump/loop to the operating storage tank while isolating the non-operating pump/loop and tank.

f. CONTRACTOR shall furnish all interconnecting piping between the limestone slurry feed pump area and the absorber and the return loop pipe to the limestone slurry tank as hereinafter specified. The

pipe used for limestone slurry shall be FRP pipe with internal abrasion resistant coating and external UV protection.

201.16. Gypsum Dewatering System

a. The dewatering equipment shall be provided complete with hydroclone feed tanks and agitators, hydroclone feed pumps, hydroclones, belt filters, vacuum pumps, filtrate receiver vessels, filtrate pumps, reclaim water tanks and all piping and valves.

b. All equipment provided for the gypsum dewatering system shall be capable of producing wall-board grade gypsum with target solids content of > 90%.

c. The absorber bleed from each unit shall be pumped via a continuous loop to the hydroclone feed tanks.

d. The dewatering building shall enclose the belt filter, filter feed pumps, filtrate feed pumps, filter vacuum pumps, filtrate receiver and reclaim water pumps.

201.17. Gypsum Dewatering Equipment - Hydroclones

a. CONTRACTOR shall furnish all equipment utilizing hydroclone separators to thicken the gypsum slurry produced at maximum (design) conditions to nominally 50% solids. The underflow will discharge to the hydroclone underflow storage tank. The overflow water from the hydroclone shall flow to the recycle water tank. Underflow and overflow connections shall be rubber lined and shall be either flanged or quick disconnect design. The hydroclones shall be located in close proximity to each Unit's absorber.

b. The system shall include hydroclone underflow tanks sized for 4 hours of storage located in close proximity to each Unit's absorber. From the hydroclone underflow tank, solids shall be pumped to a filter feed tank located in the dewatering building.

c. CONTRACTOR's process shall bleed slurry to the hydroclones based on the solids content of the slurry recycle tank and continuously sample the content of the slurry recycle tank for pH and solids content.

d. The hydroclone system shall be designed to control the particle size in the final gypsum product and to control the chlorides in the process. The CONTRACTOR shall provide a written description of the particle size control. The system shall have the following features:

d1. Hydroclones shall be lined with abrasion resistant ceramic including vortex finder and apex inserts. The lining shall be replaceable. The vortex finder and apex inserts shall be interchangeable with other sizes, and shall be selected such that one size larger and one size smaller sizes are available for performance adjustment and optimization.

e. If required by CONTRACTOR's design a small surge tank shall be provided to feed the hydroclones.

f. Hydroclones shall be constructed of housing sections consisting of cast aluminum or carbon steel. Each hydroclone shall be of a sectionalized design with replaceable ceramic liners.

f1. Hydroclone manufacturer shall supply a manifold system, with hydroclones, isolation valves, feed distributor, overflow and underflow collection launders, and structural steel support skid.

f2. The manifold design shall permit convenient removal of any hydroclone without disturbing other hydroclones for disassembling the manifold system. Blanked-off connections shall be provided for any unused hydroclone feed outlet pipes.

f3. The hydroclones shall be independently supported with no interference for vertical removal. Hydroclones shall be mounted vertically for long-term convenience in accessing apex for adjustment or inspection or at an angle if required for the application.

f4. The feed distributor shall be completely rubber lined.

f5. A half nipple with isolation valve and a pressure gauge shall be located in the feed manifold dome for inspection by operators.

201.18. Dewatering Equipment - Tanks, Agitator and Pumps.

a. The CONTRACTOR shall furnish the required reclaim water tanks, agitators, pumps, piping and associated instrumentation and controls for the dewatering process in accordance with the requirements specified herein.

b. Side mounted agitation for the reclaim water tanks is acceptable. Top mounted agitators shall be supplied for all other tanks.

c. The reclaim water tank shall be sized for a sufficient surge capacity of the hydroclone overflow and vacuum filter to satisfy start-up, shut-down and load change demands. The reclaim water tank shall be sized such that it shall not overflow under any operating conditions.

d. The tanks shall be constructed of a corrosion resistance material or of carbon steel construction and lined with a corrosion resistant coating. Materials of construction for the tanks in the dewatering area shall be subject to the review and approval of the DISTRICT's Project Engineer and the Consulting Engineer.

201.19. Dewatering Equipment – Belt Filter System

a. CONTRACTOR shall furnish all equipment and appurtenances for the belt filters including vacuum pumps, filtrate receiver tanks, blowers, cloth wash tank and pumps. The filter shall produce dry gypsum at a solids content level specified herein. Dewatered solids will be transferred by DISTRICT's stacker/conveyor system. The filtrate shall be collected in a filtrate receiver tank and pumped to one of two reclaim water tanks. From the reclaim water tanks, the water will be pumped back to the ball mills.

b. The horizontal vacuum belt filters shall be of continuous operation design. Each filter system shall be capable of continuous operation, processing gypsum material at maximum load and coal sulfur content. Filtrate from the filters shall be returned to the reclaim water tanks in the dewatering area. Horizontal vacuum filters shall comply with the following:

b1. The horizontal vacuum filter frames shall be corrosion resistant material suitable for the expected chloride concentration.

b2. The filter feed, wash, and vacuum boxes shall be alloy construction suitable for the expected chloride concentration.

b3. The filter belt shall be made of a synthetic rubber material suitable for the application.

b4. Vacuum boxes shall be designed with a lowering mechanism allowing the vacuum box to be made accessible for maintenance and cleaning.

b5. The filter cloth shall be chosen to optimize filtering characteristics, minimize cloth blinding, and prolong cloth life. Both sides of the belt shall be washed with spray nozzles.

c. The quoted price shall include recommended spare parts including as a minimum for each filter furnished; 4 replacement fabric cloths, 2 sets of vacuum box seals, one of each size roller bearing, and as recommended by the manufacturer.

d. Filter nozzles, valves and piping shall be FRP or more corrosion resistant material suitable for the chloride concentration specified herein.

e. The filter drive unit shall be variable-speed, direct connected, and controlled through the DISTRICT's DCS with vendor supplied logic.

f. CONTRACTOR shall furnish a minimum of one full capacity vacuum pump for each horizontal vacuum filter. Vacuum pumps shall comply with the following:

f1. Vacuum pumps shall be ring type, water sealed, and of cast iron construction with stainless steel sleeves.

f2. Vacuum pumps shall have direct drive. (Gear reducer is acceptable, if required.) V-belts shall not be used.

f3. Each vacuum pump shall have a Burgess-Manning Type WSD water separator snubber with an automatic seal water control valve and strainer.

f4. Each vacuum pump and snubber shall be mounted on a fabricated steel sub-base.

f5. One filtrate receiver shall be provided for each vacuum filter including the following features:

f5.1 One manway.

f5.2 One liquid level gauge.

f5.3 One high liquid level alarm.

f6. A minimum of one receiver filtrate pump shall be provided for each vacuum receiver. The filtrate pumps shall be horizontal centrifugal type with mechanical seals. The pumps shall be Alloy or rubber-lined with an Alloy impeller and hardened throat bushing. CONTRACTOR shall be responsible for selecting Alloys suitable for their intended conditions and service and subject to the review and approval of the DISTRICT's Project Engineer and the Consulting Engineer. An alternate design with the filtrate pump mounted on the receiver tank flange is acceptable.

f7. A fabricated steel sub-base shall be provided for each vacuum receiver/receiver pump set. The vacuum pump/snubber skids shall be located remote from the vacuum receiver/receiver pump skids.

f8. An automatic seal water control valve and strainer shall be provided.

201.20. Sumps and Sump Pumps

a. CONTRACTOR shall also provide the design of sumps in areas that need a sump. CONTRACTOR shall provide the sumps and drain trench system in accordance with CONTRACTOR's design to

accommodate required absorber vessel drain flow, equipment wash down, pipe flushing, and rainfall runoff. Sump discharge shall be designed as follows:

a1. The limestone preparation/gypsum dewatering sump shall discharge to the filter feed tank.

b. The absorber area sump(s) shall discharge to the absorber and to the maintenance tank.

b1. In the event that a tank requires maintenance, all tanks shall be designed to be evacuated by pumping out the contents using the process pumps until the minimum agitator level is reached. The remaining contents shall be evacuated by draining to the local sump using the tank drain.

b2. The requirements for sump pump design are specified in Section 432143.

b3. Sump agitators shall also be provided and designed per Section 432216.

201.21. Oxidation Air Blowers

CONTRACTOR shall furnish two (2), 100% capacity oil-free compressors per absorber unit for the application, performance and operating characteristics specified. Each packaged compressor unit shall be complete with remote control panel, provisions for remote monitoring and control and as specified herein. Materials selected shall be appropriate for the service.

201.22. Ductwork

a. Flue gas ductwork and expansion joint requirements are specified in Section 051800. Dampers shall not be provided.

b. Ductwork material of construction shall be in accordance with this specification.

c. The quantity and location of all test, instrument, drains and sample ports located in the ductwork shall be subject to the DISTRICT's review.

d. Ductwork shall be arranged as required by the WFGD systems design and results of the airflow model tests, and for accessibility for monitoring and testing, use of space, and appearance for each unit.

e. The maximum operating conditions and excursion conditions are specified herein.

f. Absorber Ductwork

f1. The outlet elbow/cone of the absorber shall be designed to be able to be cut and rotated 180 degrees or 90 degrees in either direction to accommodate possible future CO_2 capture equipment without impacting the performance of the absorber and mist eliminators.

f2. The final shape of the duct shall be carefully chosen based on input from the flow model testing. The expansion joint at the chimney inlet shall be by the CONTRACTOR. The allowed spacing between WFGD absorber outlet ducts at interface points at the flanges of the stack breeching ducts as well as the size of the chimney breeching will be determined by Others.

201.23. Linings and Materials of Construction

a. CONTRACTOR shall advise its sub-vendors and subcontractors of the composition of the material being handled by their Equipment.

b. CONTRACTOR shall be responsible for the design of the shop and field-erected tanks for this project (including tank and tank liner material selection), subject to the review and approval of the DISTRICT's Project Engineer and the Consulting Engineer. Where rubber linings or specific alloy materials are called for herein, CONTRACTOR shall verify the suitability of the specified material or specify another material, but said material shall be of higher quality in regard to corrosion- or erosion-resistant performance. CONTRACTOR shall not substitute a material of lower quality. Material selection shall be subject to the review and approval of the DISTRICT. Shop applied linings shall be supplied by the CONTRACTOR. Linings for field fabricated tanks shall be supplied and applied in the field, by the CONTRACTOR.

c. Linings, including reinforced resin coatings, fluoroelastomer coatings, rubber, synthetic rubbers, and ceramic shall include the following requirements:

c1. The ball mill product tanks shall be shop rubber lined.

c2. CONTRACTOR shall consider lining weights in its tank design, duct design, and hanger design.

c3. The design details of tanks, ducts, and vessels to be lined shall include continuous internal welding on plates and support members, matted or rounded corners, and no sharp edges of any kind.

c4. CONTRACTOR shall prepare all surfaces for lining. Depth of profile and sand used for blasting shall meet the minimum requirements specified by ASTM 4618-92.

c5. CONTRACTOR shall inspect all surfaces to be lined and correct all defects in workmanship which shall prevent proper application of, or lead to premature failure, of linings.

c6. CONTRACTOR shall advise the DISTRICT when surfaces are ready so the DISTRICT's inspector can inspect all surfaces to be lined prior to application of the lining.

d. Flake linings shall contain glass, and not mica.

e. CONTRACTOR shall recommend suitable corrosion- and erosion-resistant materials for building floors, and exposed steel in all areas of the flue gas cleaning system.

f. CONTRACTOR shall follow ASTM STP 837 in the application of all coatings and linings. Documentation for all aspects of the lining work shall be available to DISTRICT throughout the lining work.

g. CONTRACTOR shall clean and passivate all alloy surfaces after installation to ensure maximum life. Procedures for cleaning and passivation shall be in accordance with the recommendations of the alloy supplier, CONTRACTOR and ASTM STP 837.

201.24. Miscellaneous Requirements

a. Rotating equipment shall be direct driven and not belt or chain driven, except for smaller slurry pumps (150 HP and less) which may be belt driven. If there are other applications requiring belt driven equipment, the CONTRACTOR shall provide technical and economic justification for their use. V-belt drives shall be of the multiple matching belt type with steel sheaves having a horsepower rating of not less than 100 percent of the rated horsepower of the motor drive or 115 percent of the rated horsepower if the motor has a 1.15 service factor, and shall have at least one more belt and groove than required for 100 or 115 percent rated horsepower of the motor drive.

b. Shop Tests: The CONTRACTOR shall inform the DISTRICT's Project Engineer and Consulting Engineer a minimum of three weeks prior to performing equipment shop tests. The DISTRICT's Project engineer and Consulting Engineer reserve the right to witness shop tests.

c. All equipment shall be designed to permit washdown (e.g., location on elevated housekeeping pads, etc.)

201.25. Equipment Cleaning and Painting

a. Coating and painting requirements are specified herein.

b. Where the CONTRACTOR believes that the equipment or piping conditions and service exceed the requirements for painting in this specification, the CONTRACTOR shall bring it to the attention of the DISTRICT and/or Engineer and provide recommended alternatives for their consideration, review and approval.

c. A sufficient quantity of each kind of shop paint used shall be shipped to the project site by CONTRACTOR for the DISTRICT's use as touch-up paint after erection.

201.26. Vessel Inspection and Testing

a. In addition to other inspection and testing required by this Specification and the applicable requirements of the standard specifications, the following requirements shall also apply.

b. Pressure Vessels: Before shipment and before painting, CONTRACTOR shall inspect all shop fabricated pressure vessels and prove them tight, as required by Section VIII or Section X of the ASME Boiler and Pressure Vessel Code. Equipment shall be acceptable for insurance as unfired pressure vessels. ASME Code stamp is required and inspection certificates shall be furnished to DISTRICT for all pressure vessels.

202. CONTROLS & INSTRUMENTATION PHILOSOPHY

202.1. General

a. The systems and accessories included within the scope of work contained herein shall be automated to the greatest extent possible and shall be capable of automatic control at all loads.

b. Unless noted otherwise, all systems and accessories provided by the CONTRACTOR shall be controlled, monitored and alarmed via the WFGD distributed control system (DCS) for each unit. The equipment common to both units (e.g. reagent preparation, dewatering, etc.) shall be controlled through the DCS of the WFGD system that first comes on-line. Programmable logic controllers (PLCs) with the exception of the Oxidation Air Compressor PLC and Instrument Air Compressor PLC, single loop controllers, pneumatic controls, electrical relay based controls or hardwired logic and interlocks implemented outside the DCS are unacceptable and shall not be provided, unless approved by DISTRICT. CONTRACTOR shall provide project specific control logic diagrams in SAMA format and project-specific description of operation documents for all equipment and/or systems. CONTRACTOR's control logic diagrams, control logic descriptions, I/O and alarm set points and lists shall be used by the DISTRICT, the DCS vendor or others for programming and configuring the DCS. CONTRACTOR is required to participate in the factory acceptance testing of the DCS and to certify that the DCS logic has been implemented per CONTRACTOR's control logic diagrams including any requirements for operation and performance. The CONTRACTOR shall not claim the DCS as the limiting factor in the operation and performance of CONTRACTOR's equipment and/or systems. The

system control logic shall also allow for the system to safely shutdown in the event of a unit trip, main boiler feed pump trip, ID fan trip and WFGD recycle pump trip.

202.2. Control Design Basis - General

a. The philosophy shall be to provide control logic, which shall provide stable operation and shall minimize unit trips. The control logic shall provide an automatic means to stabilize unit operation in an attempt to prevent occurrences of unit trips. Upon detection of such conditions, the following actions listed below shall be initiated, until the threat of a trip is eliminated:

a1. Provide adequate plant alarms to detect abnormal conditions.

a2. Rundown unit load demand at a predetermined rate until the condition improves.

a3. On loss of an auxiliary, runback the boiler/turbine to a predetermined unit load demand, at a controlled runback rate. CONTRACTOR shall advise the need to implement a unit load runback for unavailability or trip of a critical piece of equipment furnished by CONTRACTOR.

b. There are three levels of protection and control philosophies with each level having a minimum requirement for field instrumentation redundancy. The three levels are Plant Protection, Plant MW Output Integrity and Non-critical Systems and are described in more detail as follows:

b1. Plant Protection

b1.1 The following applies to critical control loops and auxiliaries that if operated out-of-limits will cause loss of power generation or potentially cause catastrophic damage to a major plant auxiliary.

b1.1.1 The control system shall be fault tolerant such that no single component failure shall cause a failure or interruption of control and monitoring functions.

b1.1.2 The control logic for triple redundant field instrumentation shall perform median select logic for analog loops and 2-out-of-3 logic for digital loops. Triple instrumentation shall be used for pH control loops.

b2. Plant MW Output Integrity and Equipment Trips

b2.1 The following applies to the controls for systems and auxiliaries that if operated out-of-limits shall directly affect plant operation or output, or cause damage to major auxiliaries.

b2.1.1 The control system shall be fault tolerant such that no single component failure shall cause a failure or interruption of control and monitoring functions.

b2.1.2 The control logic for dual redundant field instrumentation shall perform average select logic of the two analog signals or 2-out-of-2 logic for digital signals.

b3. Non-Critical Systems

b3.1 The following applies to systems for which a control system failure can be easily rectified before plant operation or output is affected. An example of a system using this philosophy would be a cooling water temperature control valve using a single temperature input.

b3.1.1 Non-redundant controls, for these systems it is acceptable that a single component failure shall cause a failure or interruption of control and monitoring functions.

b3.1.2 Single instrumentation, for these systems a single instrument for control and monitoring is acceptable.

c. Fail-Safe Design

c1. In general, plant systems shall be designed to be fail-safe. Upon loss of the control signal, or control or motive power, the control system and devices shall fail to the position that cannot cause equipment damage or injury.

d. Alarm and Protection Circuits

d1. Generally, alarm circuits are closed to alarm and protection circuits are de-energized to trip. The decision to use open or close contacts for alarming and energizing or de-energizing to trip depends on the system configuration and equipment, and the priorities of the system and the control, including instrumentation. For example, if it is more important to keep equipment running than it is to prevent damage by stopping it, energizing to trip may be more appropriate than de-energizing. It is the responsibility of the CONTRACTOR, by using good engineering judgment and knowledge of the system under consideration to make this determination on a case by case basis.

e. Interlocks

e1. Interlocks shall be incorporated to ensure the safe, sequential start-up and shutdown of the system equipment. Sufficient interlocks, timing, circuits and monitoring shall be provided to ensure proper operations, maximum safety and reliability under all modes of operation, and to minimize operator actions or equipment failure from creating unsafe conditions or damaging equipment.

f. Manual Operation

f1. All protective trips, permissives and interlocks shall be active in the Automatic mode. While in the manual mode the plant operator shall be responsible for operation. However, consideration shall be taken as to whether a protective trip or permissive condition is active with the controls in the manual mode. In general, protective trips shall be active regardless of whether the controls are in automatic or manual. Certain permissives shall also be active even in the manual mode as required in order to protect auxiliaries. For example, lube oil pressure adequate as a start permissive for a pump. In general, most interlocks will be defeated if the controls are in manual. An alarm can be generated to alert the operator that action is required if an interlock is defeated. An example would be a 2 x 100% pump scheme where the primary pump trips off and the standby pump should auto start, but does not since it was left in manual. The alarm alerts the operator to take action to get the second pump started.

202.3. Control Logic Implementation

a. Plant Protection

a1. The following considerations and criteria are the general requirements for protection of the power plant.

a1.1 The control system shall include logic that automatically protects the equipment from exposure to damage. Equipment protection designs shall be in proportion to equipment cost or its effect on the cost of operations, but protection designs shall never compromise personnel safety.

a1.2 The protective logic shall isolate the faulted equipment while maintaining unaffected equipment on line, whenever possible, and minimize the amount of time required to re-establish proper operation and to bring systems back on-line.

a1.3 If the detected fault creates a risk of damage to other systems, the protective logic shall initiate actions to protect the plant from damage.

a1.4 In general, on failure of a controller function, protective trip outputs must fail to the safe (usually tripping) position. A total loss of control power must result in a trip of equipment that has trip protection. Other equipment, (such lube oil or seal oil systems), which are required to prevent damage during the shutdown of other systems, shall be designed to remain in the run state in the event of a total control system fault.

a1.5 Consideration shall be given to the utilization of redundant transducers and/or qualification of critical inputs. When the loss of one input could require manual operation of a significant portion of the controls, or disables protective logic, redundancy shall be employed.

a1.6 Where pilot-solenoid actuated, air-operated valves are used in protective circuits, the solenoids shall be de-energized to provide the protective action, and the air actuator shall vent to provide the protective action. In other words, the valve will fail in the safe position upon either a loss of electrical power to the solenoid, or a loss of air power to the actuator.

a1.7 Where pilot-solenoid actuated, air-operated valves are used in control override applications, the solenoids shall be energized to provide the override action, and the air actuator shall be pressurized to provide the protective action.

b. Plant Control

b1. The control system shall perform both modulating and discrete logic control on the majority of the plant processes and equipment. The control system shall also serve as an operator interface to monitor BOP packages that have self-contained control.

b2. The control system shall provide a consistent operator interface to control functions throughout the system, with identical philosophies for status and mode indication, operator actions, etc.

b3. The control system shall utilize thresholds of analog transmitter input values to create digital points for discrete logic control and interlocks instead of the use of field mounted process switches. The use of process switches shall be minimized since process switches fail without warning and could potentially cause a trip condition to be missed or degrade a 2 out of 3 redundancy scheme. All analog values shall be monitored and alarmed for being outside reasonable limits.

b4. The closed-loop controls shall be incorporated into each modular controller for automatic control of the major subsystems. The control loops shall regulate flows, pressures, temperatures and levels through variable measurement, comparison with a setpoint or demand, and control action by a control valve/actuator. Control setpoints may be fixed or variable based on a parameter, and shall be determined by the "unit" level control microprocessor, not from a higher level processor such as an operator console server. Completely automatic operation of the loops shall be standard; however, the operator may elect to take over remote manual operation of an actuator from the operator console.

b5. All analog values shall be monitored and alarmed for being outside reasonable limits. Alarm conditions or levels shall be established to allow for operator action before a subsequent trip. All alarm and trip functions shall be displayed in the operator workstations. The alarm circuits shall be designed to show no alarms when the monitored equipment or system is operating normally. Alarm inhibit logic shall be implemented to prevent nuisance alarms (e.g., low pump discharge pressure will be inhibited by pump not running).

202.4. Control Logic Preparation

a. The controls for each WFGD systems shall be standardized to the largest extent possible in order that all auxiliaries controlled by the DCS operate in the same manner. CONTRACTOR shall provide standard control logic, known as master logic, for DISTRICT's review and acceptance, and use this logic in its control logic design. Additional details are defined below.

b. As a minimum, standard control logic shall be developed for the following device types:

b1. Medium / low voltage switchgear motor

b2. Medium / low voltage switchgear breaker

b3. 480V non-reversing motor, starter at MCC

b4. 480V reversing MOV, full open/full close, torque seat close, starter at MCC

b5. 480V reversing MOV, full open/full close, non-torque seat close, starter at MCC

b6. 480V reversing MOV, throttling, torque seat close, starter at MCC

b7. 480V reversing MOV, throttling, non-torque seat close, starter at MCC

b8. 480V reversing damper drive, full open/full close, starter at MCC

b9. 480V reversing motor or fan, starter at MCC

b10. 120VAC single solenoid, fail open

b11. 120VAC single solenoid, fail closed

b12. 120 VAC dual solenoid

b13. Other devices as required

c. Master Logic Drawings

c1. Standard control logic shall be developed by the CONTRACTOR for every device listed above. This logic will not change from service to service and is called "master logic". The master logic shall define the operation of the device including permissives, auto start, auto stop, protective overrides, etc. and shall include provisions for tagout. Additionally, each master logic drawing shall define standard alarms generated within the logic such as "Fail to Start", "Fail to Stop", etc. The master logics, once developed and agreed upon, shall be frozen to discourage changes as the project progresses. The control logic drawings developed for specific services shall represent the master logic in outline form showing just the digital I/O for "Auto Start", "Start Permissive", etc. without showing all the details within. By using this format changes can be made, if required, to the master logic without impacting the service logic.

d. Drive Level Control

d1. Control of motorized equipment is performed at the Drive Level. Each piece of equipment is categorized as a specific type (i.e. motor operated valve, switchgear breaker, etc.). Each type will have an associated master logic "macro" which defines the operation. The control logic for a specific service will utilize the macro logic and associated "steering" logic to produce the required interlocks, permissives, auto starts, auto stops, trips, etc. Provisions are included for automatic and manual operation. Each piece of equipment shall have a corresponding DCS graphic faceplate.

202.5. Instrumentation and Controls Specifications

Unless otherwise specified, all instrumentation and controls shall conform to the requirements of Section 409119, "Instrumentation and Controls Specifications and Installation Requirements."

202.6. Local Control Panel Requirements

Unless otherwise specified, operation of equipment shall be remote via the DCS. If CONTRACTOR provides control panels for local control of equipment, the following functional requirements shall apply. All controls mounted on local control panels, including but not limited to: control switches, pushbuttons and indicating lamps shall be wired directly to the DCS in order to maintain control indication, interlocking, monitoring and alarming. The DCS shall perform all logic for the local control panel. The local control panel shall not contain any hardwired relays or perform any control independent of the DCS. CONTRACTOR's control logic shall include provisions for coordination between local control operation and remote operation from the DCS.

202.7. WFGD Systems Instrumentation

a. WFGD System "Flue Gas Side" Control for each WFGD system

a1. CONTRACTOR shall provide a list of signals required from the DISTRICT's combustion control system to the WFGD System "wet side" DCS as part of the functional descriptions.

a2. The DISTRICT will provide monitoring and control instrumentation for any required signals outside the scope of equipment being supplied by the CONTRACTOR.

a3. FGD System "Wet Side" Control – The DCS monitoring and control instrumentation provided by the CONTRACTOR shall include, but not be limited to, the following. CONTRACTOR shall also include any controls and monitoring required due to the unique character of its equipment.

b. Water Flow

b1. Makeup water from the quench tank to the absorber. Mist eliminator water from the wash tank to all spray levels in the modules. Makeup water to oxidation air humidification, ball mill, or as module makeup.

c. Slurry (or solution) flow

c1. Limestone reagent slurry flow entering the absorber.

c2. Absorber bleed slurry from the absorber to the dewatering system.

d. Gas Flow

d1. Absorber spray zone differential pressure instrumentation to allow monitoring of individual absorber module gas flows.

d2. Pressure drop across each spray zone, mist eliminator, and the entire system.

e. Measurement of pH

f. Slurry in the absorber reaction tank.

g. Specific gravity or density measurements of slurry (or solution).

h. Solids concentrations in the absorber recycle tank and hydroclone underflow

i. Process temperatures and pressures throughout the system.

j. Level

j1. Level control with high and low alarms for the reaction tank

j2. High and low level alarms in all WFGD tanks

j3. Level indication in all WFGD tanks, scaled 0%-100%.

k. Flue Gas Temperatures:

k1. Entering the absorber.

k2. Leaving the Absorber.

l. CONTRACTOR shall furnish all field pressure, temperature, and flow instrumentation required to promptly monitor the equipment in accordance with good engineering practice.

m. CONTRACTOR shall furnish the necessary structures to implement safety interlocks and alarms for all motor-operated components furnished in accordance with this specification. Interlocks and alarms are to be identified on CONTRACTOR's logic diagrams in accordance with the following criteria:

n. CONTRACTOR's logic shall be based on control of motors either fed from switchgear or motor control center. Whether a motor is fed from switchgear or from a motor control center shall be based on horsepower of each motor which will be advised later. The signal interfaces to be used by the CONTRACTOR in the logic diagrams based on signal interfaces to be advised by DISTRICT later.

o. Alarms for motors shall be used to identify the failure of motors to start when required and to identify motor trips other than manual trips. The WFGD DCS will provide alarm management and will eliminate hand switches, except for emergency stop switches.

p. Oxidation Air Compressor Requirements

p1. CONTRACTOR shall provide a programmable logic controller (PLC) to control the air compressor equipment. CONTRACTOR can provide either a single, non-redundant PLC per compressor train, or a common redundant PLC configuration for control of all compressors. For purposes of this specification, whether redundant or single, it shall be referred to as "PLC".

p2. The PLC shall perform analog process control, digital logic control and alarming/annunciation. A limited amount of logging, trending and, historical data storage and retrieval shall be available. All PLC configuration memories shall be nonvolatile.

p3. Integration to Plant DCS

p3.1 The DCS shall act as the supervisory control system, to monitor system parameters and alarms and to provide basic overall commands such as system start and stop for the purposes of coordinated start-up, shutdown and equipment protection. Supervisory control signals between the DCS and PLC shall be hardwired. Alarm and indication signals between the DCS and PLC shall be via an Ethernet TCP/IP datalink connection. The datalink shall be non-redundant if a single PLC per air compressor/dryer configuration is implemented. The datalink shall be redundant if a common, redundant PLC is used for all compressors/dryers.

p3.2 All PLC alarms shall be sent to the DCS via the datalink, and the use of common trouble alarms shall be avoided. The datalink shall allow the DCS to acknowledge the PLC alarms. The DCS shall also perform all logging, trending and, historical data storage and retrieval.

p3.3 The DCS shall control the switchgear or MCC that feeds CONTRACTOR's air compressor motor. The switchgear or MCC shall stay energized and the air compressor shall load and unload based on

demand. The DCS shall trip the switchgear or MCC based on command from CONTRACTOR's PLC for machine protection.

p4. PLC Control Panel Requirements

p4.1 CONTRACTOR's PLC control panel shall be located on or near the air compressor equipment and shall be rated NEMA 4. CONTRACTOR's standard NEMA 4 LCD HMI shall be provided at the equipment for local operation. CONTRACTOR's PLC shall be designed to accept an independent 120Vac power source in order that the PLC does not de-energize upon trip of the power feed to the air compressor motor.

p5. System Outlet Header Pressure

p5.1 CONTRACTOR shall provide redundant pressure transmitters on the system outlet header, wired to CONTRACTOR's PLC, for monitoring and developing the demand signal for control of the air compressors. The PLC shall perform averaging logic and pass the outlet header average pressure to the DCS via the datalink.

p6. Machine Monitoring, Protection and Alarming

p6.1 CONTRACTOR shall provide instrumentation on each compressor for the purpose of machine monitoring, protection and alarming. Abnormal levels shall initiate an alarm, and critical levels shall initiate an equipment shutdown and alarm. CONTRACTOR shall provide instrumentation for the following compressor parameters, including but not limited to: bearing vibration, oil pressure, oil temperature, cooling water temperature, discharge air temperature, high filter differential (each filter). The PLC shall transmit the machine parameters and alarms to the DCS via the datalink

END OF SECTION 441130